

THE COMPLEAT SURVEYOR:

Containing
The whole *A R T* of
Surveying of Land,

BY THE
Plain Table, Theodolite, Circumferentor,
AND
P E R A C T O R:

After a more easie, exact and compendious
manner, then hath been hitherto published by any: the
PLAIN TABLE being so contrived, that it alone
will conveniently perform whatsoever may be done by
any of the fore-mentioned *Instruments*, or any
other yet invented, with the same ease
and exactnesse; and in many
cases much better.

Together with the taking of all manner of
Heights and Distances, either accessible or in-accessible, the Plotting
and Protracting of all manner of Grounds, either small Inclosures,
Champion plains, Wood-lands, or any other Mountainous and un-even
grounds: Also, How to take the Plot of a whole Mannor, to
cast up the content, and to make a perfect Chart or
Map thereof. All which particulars are per-
formed three severall wayes, and by
three severall Instruments.

Hereunto is added, the manner how to know
whether Water may be conveyed from a Spring head to any
appointed place or not, and how to effect the same: With
whatsoever else is necessary to the Art of
SURVEYING.

By WILLIAM LEYBOURN.

L O N D O N :

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and



TO HIS MUCH
HONOURED FRIEND
EDMUND WINGATE,
of *Graves Inne*, Esq;

S I R,



His *Treatise* being finished, and ready to see the light, I could not but think my selfe of a fitter Patron then your selfe to protect it; Your knowledge in, and affection to the Sciences *Mathe-maticall*, as also the civill respect which You usually vouchsafe such as affect those Studies, arme me with this confidence.

I foresee that this my presumption in exposing this Work to publique view, may meet

The Epistle Dedicatorie.

with some Detractors, but Your approbation thereof, will both convince them of their Errour, and plentifully satisfie me for the pains I have taken therein. Howbeit, what reception soever it may obtain with the Vulgar, my intention (I doubt not) will give me support and encouragement, my ayme therein being nothing else but the publique good; and this my Dedication an evidence to let You know how much I am,

S I R,

*Your most humble and
obliged Servant,*

WILLIAM LEYBOURN

TO THE READER.

Comtious Reader

Now three years since there came into the World a little Pamphlet entitled *Platysternus*, or the whole art of Surveying of Land, under the name of *Mathew Waller*, of which I confess my self to be the Author; that name being only the true letters of my own name transposed, and was indeed very unwilling the world should know me to be the Author thereof, in being so inattentive to the title, and too particular for a Subject of so large an extent; but that was occasioned by overmuch haste, for (being urged thereto) it was not above six weeks conceived before it was brought forth; and therefore must needs be little less than monstrous; yet the good acceptance which that pamphlet obtained, I occasioned me to perfect that Subject more at large.

Now as the opinions of men in the world are various, so I think this work will be variously received; and therefore it might (perchance) be expected by some, that I should make some apology for my self; as to praye pardon, I cannot for this I desire any man shall be pleased to object against, but I mean no other but to excuse it of nothing that needs it, neither did I ever know any Book so much favoured for the Author, but taking in all sides, the Subject of this ensuing Treatise being Geometry, needed no such thing; for I desire to see the good of the world, and to be able to win all opposers, and silently with I hope and desire to see the most malicious tongues as parasites that shall speak no more against it. But to the judicious Reader I shall say thus much, As I dare not think my doings free from all exceptions, so I dare not know any thing herein contained worthy deserving blame; So it is small oversight which may possibly here or there by chance I have introduced, I beseech the friendly Reader to excuse me, as I will do so, as will he ever slight mistake or error in the printing, as for technical faults I know of none in the whole Work, although I have diligently examined the printed sheets.

To the Reader.

In the following Treatise I have endeavoured to proceed methodically, and to insert every particular Chapter as it ought to be read and practised, and have omitted nothing that might any way tend to make a man in short time become an exquisite proficient in the Geometrical part of Surveying.

The first part of this Book consisteth of Geometry only, and containeth such Problems as are meet and necessary to be known and practised by any man that intendeth to exercise himself in this employment: by help of these Problems the plot of any piece of Land may be enlarged or diminished according to any assigned proportion, and separation and division thereof made, if need be, by Rule and Compasse only, and also by Arithmetick.

In the second Book, you have a general description of all the most necessary Instruments used in Surveying, as of the *Theodolite*, *Circumferentor*, *Plain Table*, and the like, and more particularly of those which I make use of in the prosecuting of this discourse. Also I have given such directions for the making of the *Plain Table*, and furnished the Index and other parts thereof with diverse necessary lines for severall occasions, so that it being made according to the directions there given, it is the most absolute and universall Instrument yet ever invented, for by it may be performed whatsoever may be done by the *Theodolite*, *Circumferentor*, or *Bevel*, with the same facility and exactness, and in many cases better, as in the particulars use thereof will plainly appear.

The third Book is of *Trigonometrie*, or the Doctrine of the dimension of Plain Triangles, by *Sines*, *Tangents*, and *Logarithms*, by which the nature and reason of the taking of all manner of Heights and Distances may the better appear, and for that reason I have in this third Book added short Tables of *Sines* and *Logarithms*, namely a Table of *Sines* to every 10 minutes of the Quadrant, and a Table of *Logarithms* from 1 to 1000, by which more Questions may be resolved in the space of one hour, then by the usual wayes taught by others can be performed in six, if the like exactness be required. And for a further abbreviation of these Calculations, I have also showed how to resolve all such Cases in Plain Triangles as they at any time come in use in the practise of Surveying by the lines of Artificiall *Numbers*, *Sines*, and *Tangents*, whereby all such Cases may be resolved without pen, ink or paper.

In the fourth Book is shew'd the use of all the fore-mentioned Instruments in the practise of Surveying, and first, in the taking of all manner of Heights and Distances either on a hill or in a plain, in the practise whereof the young practitioner will find much delight, and receive no small satisfaction.

There is also taught how to take the plot of any field or other inclosure several wayes, both by the *Plane Table*, *Circumferentor*, and *Circumferentor*, by which will appear what order and harmony there is between the severall Instruments, for if you take the plot of any field by any one of them, and then by another of them, and plot your work by the same Scale as both your observations, you shall

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GENERAL SURVEY

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Orasmuch as the whole
Art of Surveying of
Land is performed by
Instruments of seve-
rall kindes, and that
the exact and carefull
making and dividing
of all such Instruments is chiefly to be aimed
at, I thought good to intimate to such as are de-
sirous to practise this Art, and do not readily know
where to be furnished with necessary Instruments
for the performance thereof, that all, or any of the
Instruments used or mentioned in this Book, or
any Mathematicall Instrument whatsoever is
exactly made by Mr. Anthony Thompson in
Hosier lane neer Smithfield, London.



THE COMPLEAT SURVEYOR.

The First Book.

THE ARGUMENT.



His first *Book* consisteth of divers *Definitions* & *Problemes* Geometricall, extracted out of the Writings of divers ancient and modern *Geometricians*, as *Euclid*, *Ramus*, *Clavius*, &c. and are here so methodically disposed, that any man may gradually proceed from *Probleme* to *Probleme* without interruption, or being referred to any other *Author* for the Practicall performance of any of them. Onely the *Demonstration* is wholly omitted; partly, because those *Books*, out of
which

which they were extracted, are very large in that particular, and also for the avoiding of many other *Propositions* and *Theoremes*, which (had the ensuing *Problemes* been *demonstrated*) must of necessity have been inserted. Also, the figures would have been so incumbered with multiplicity of lines, that the intended *Problemes* would have been thereby much darkened. And besides it was not my intent in this place to make an absolute or entire *Treatise of Geometry*, and therefore I have onely made choice of such *Problems* as I conceived most usefull for my present purpose, and come most in use in the practice of *Surveying*, and ought of necessity to be known by every man that intendeth to exercise himselfe in the Practice thereof, and those are chiefly such as concern the reducing of *Plots* from one forme to another, and to enlarge or diminish them according to any assigned *Proportion*, also divers of the *Problemes* in this *Book* will abundantly help the *Surveyor* in the division and separation of *Land*, and in the laying out of any assigned quantity, whereby large parcels may be readily divided into divers severals; and those again sub-divided if need be. Also for the better satisfaction of the *Reader*, I have performed divers of the following *Problemes* both *Arithmetically* and *Geometrically*.

G E-



GEOMETRICALL DEFINITIONS.

1. *A Point is that which cannot be divided.*



Point or *Signe* is that which is void of all *Magnitude*, and is the least thing that by minde and understanding can be imagined and conceived, than which there can be nothing lesse, as the *Point* or *Prick* noted with the letter A, which is neither quantity nor part of quantity, but only the terms or ends of quantity, and herein a *Point* in Geometry differeth from *Unity* in *Number*.

2. *A Line is a length without breadth or thickness.*

A *Line* is created or made by the moving or drawing out of a *Point* from one place to another, so the *Line* A B, is made by moving of a *Point* from A to B, and according as this motion is, so is the *Line* thereby created, whether *straight* or *crooked*. And of the three kinds of *Magnitudes* in *Geometry*, viz. *Length*, *Breadth*, and *Thickness*, a *Line* is the first, consisting of *Length* only, and therefore the *Line* A B, is capable of division in *length* only, and may be divided equally in the *point* C, or unequally in D, and the like, but will admit of no other dimension.

3. *The ends or bounds of a Line are Points.*

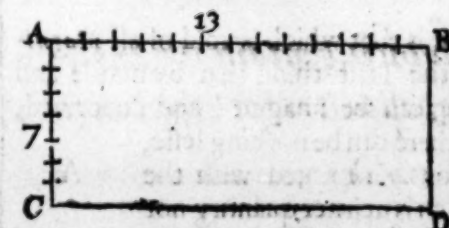
This is to be understood of a finite *Line* only, as is the line A B, the ends or bounds whereof are the points A and B: But in a *Circular Line* it is otherwise,

wise, for there, the *Point* in its motion returneth again to the place where it first began, and so maketh the *Line* infinite, and the ends or bounds thereof undeterminate.

4. *A Right line is that which lieth equally between his points.*

A _____ B As the *Right line* A B lyeth streight and equall between the points A and B (which are the bounds thereof) without bowing, and is the shortest of all other lines that can be drawn between those two points.

5. *A Superficies is that which hath only length and breadth.*



As the motion of a point produceth a *Line*, the first kinde of Magnitude, so the motion of a *Line* produceth a *Superficies*, which is the second kinde of Magnitude, and is capable of two dimensions, namely, length and breadth, and so the *Superficies* A B C D may be divided in length from A to B, and also in breadth from A to C.

6. *The extrems of a Superficies are Lines.*

As the extrems or ends of a *Line* are points, so the extrems or bounds of a *Superficies* are *Lines*, and so the extrems or ends of the *Superficies* A B C D, are the lines A B, B D, D C, and C A, which are the terms or limites thereof.

7. *A plain Superficies is that which lieth equally between his lines.*

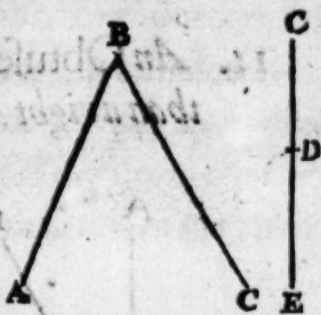
So the *Superficies* A B C D lieth direct and equally between his lines: and whatsoever is said of a right line, the same is also to be understood of a plain *Superficies*.

8. *A plain Angle is the inclination or bowing of two lines the one to the other, the one touching the other, & not being directly joyned together.*

As the two lines A B and B C incline the one to the other, and touch one another in the point B, in which point, by reason of the incli-

inclination of the said lines, is made the Angle ABC . But if the two lines which touch each other be without inclination, and be drawn directly one to the other, then they make no angle at all, as the lines CD and DE , touch each other in the point D , and yet they make no angle, but one continued right line.

¶ And here note, that an Angle commonly is signed by three Letters, the middlemost whereof sheweth the angular point: As in this figure, when we say the angle ABC , you are to understand the very point at B : And note also, that the length of the sides containing any angle, as the sides AB and BC , do not make the angle ABC either greater or lesser, but the angle still retaineth the same quantity be the containing sides thereof either longer or shorter.



9. And if the lines which contain the angle be right lines, then is it called a right lined angle.

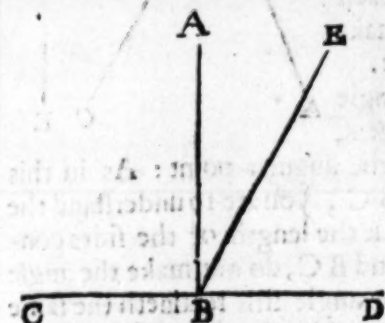
So the angle ABC is a right lined angle, because the lines AB and BC , which contain the said angle, are right lines. And of right lined Angles there are three sorts, whose Definitions follow.

10. When a right line standing upon a right line maketh the angles on either side equall, then either of those angles is a right angle: and the right line which standeth erected, is called a perpendicular line to that whereon it standeth.

As upon the right line CD , suppose there do stand another right line AB , in such sort that it maketh the angles on either side thereof equall, namely, the angle ABD on the one side, equall to the angle ABC on the other side: then are either of the two angles ABC , and ABD right angles, and the right line AB , which standeth erected upon the right line CD without inclining to either part thereof, is a perpendicular to the line CD .



11. *An Obtuse angle is that which is greater than a right angle.*



So the angle CBE is an obtuse angle, because it is greater than the angle ABC, which is a right angle; for it doth not only contain that right angle, but the angle ABE also, and therefore is obtuse.

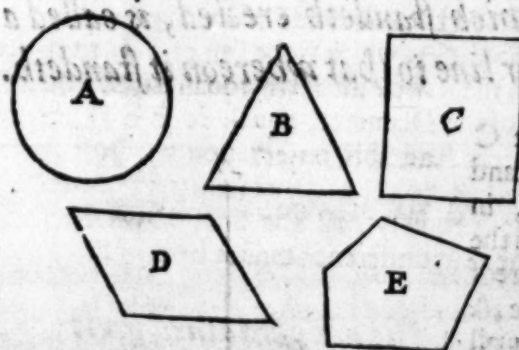
12. *An Acute angle is lesse than a right angle.*

So the angle EBD is an acute angle, for it is lesse than the right angle ABD (in which it is contained) by the other acute angle ABE.

13. *A limit or term is the end of every thing.*

As a point is the limit or term of a Line, because it is the end thereof, so a Line likewise is the limit and term of a Superficies, and a Superficies is the limit and term of a Body.

14. *A Figure is that which is contained under one limit or term or many.*

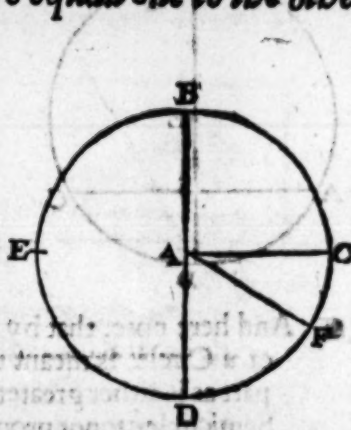


As the Figure A is contained under one limit or term, which is the round line. Also the Figure B is contained under three right lines, which are the limits or terms thereof. Likewise, the Figure C is contained under four right lines, the Figure E under five right lines, and so of all other figures.

¶ And here note, that in the following work we call any plain Superficies whose sides are unequal, (as the Figure E) a *Plot*, as of a Field, Wood, Park, Bourn, and the like.

15. *A Circle is a plain Figure contained under one line, which is called a Circumference, unto which all lines drawn from one point within the Figure, and falling upon the Circumference thereof are equall one to the other.*

As the Figure *A B C D E* is a Circle, contained under the crooked line *B C D E*, which line is called the Circumference: In the middle of this Figure is a point *A*, from which point all lines drawn to the Circumference thereof are equall, as the lines *A B*, *A C*, *A F*, *A D*: and this point *A* is called the center of the Circle.



16. *A Diameter of a Circle is a right line drawn by the Center thereof, and ending at the Circumference, on either side dividing the Circle into two equall parts.*

So the line *B A D* (in the former Figure) is the Diameter thereof, because it passeth from the point *B* on the one side of the Circumference, to the point *D* on the other side of the Circumference, and passeth also by the point *A*, which is the center of the Circle. And moreover it divideth the Circle into two equall parts, namely, *B C D* being on one side of the Diameter, equall to *B E D* on the other side of the Diameter. And this observation was first made by *Thales Miletus*, for, such be: If a line drawn by the center of any Circle do not divide it equally, all the lines drawn from the center of that Circle to the Circumference cannot be equall.

17. *A Semicircle is a figure contained under the Diameter, and that part of the Circumference cut off by the Diameter.*

As in the former Circle, the figure *B E D* is a Semicircle, because it is contained of the right line *B A D*, which is the Diameter, and of the crooked line *B E D*, being that part of the circumference which is cut off by the Diameter: also the part *B C D* is a Semicircle.

18. A Section or portion of a Circle, is a Figure contained under a right line, and a part of the circumference, greater or lesse then a semicircle.



So the Figure A B C, which consisteth of the part of the Circumference A B C, and the right line A C is a Section or portion of a Circle greater than a Semicircle.

Also the other figure A C D, which is contained under the right line A C, and the part of the circumference A D C, is a Section of a Circle lesse than a Semicircle.

And here note, that by a Section, Segment, Portion, or Part of a Circle, is meant the same thing, and signifieth such a part as is either greater or lesser then a Semicircle; so that a Semicircle cannot properly be called a Section, Segment, or part of a Circle.

19. Right lined figures are such as are contained under right lines.

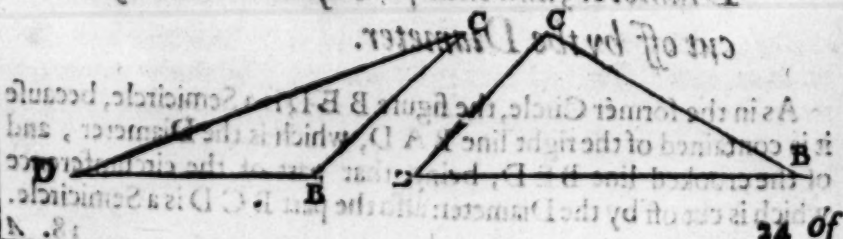
20. Three sided figures are such as are contained under three right lines.

21. Four sided figures are such as are contained under four right lines.

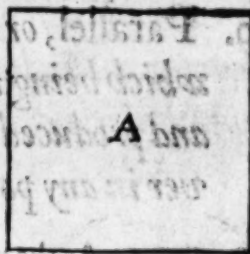
22. Many sided figures are such as have more sides than four.

23. All three sided figures are called Triangles.

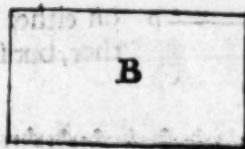
And such are the Triangles B C D.



24. Of four sided Figures, a *Quadrat or Square* is that whose sides are equal and his angles right. [As the Figure A.]



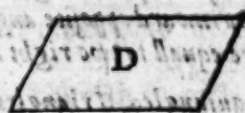
25. A *Long square* is that which hath right angles but unequal sides. [As the Figure B.]



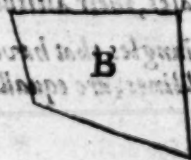
26. A *Rhombus* is a Figure having four equall sides but not right angles. [As the Figure C.]



27. A *Rhomboides* is a Figure whose opposite sides are equall, and whose opposite angles are also equall, but it hath neither equall sides nor equal angles. [As the Figure D.]



28. All other Figures of four sides (besides these) are called *Trapezias*.



Such are all Figures of four sides in which is observed no equality of sides or angles, as the figures A and B, which have neither equall sides nor equall angles, but are described by all adventures without the observation of any order.

C


29. Parallel

29. Parallel, or equidistant right lines are such which being in one and the same Superficies and produced infinitely on both sides, do never in any part concur.

As the right lines A B and C D are parallel one to the other, and if they were infinitely extended on either side would never meet or concur together, but still retain the same distance.



Geometricall Theoremes.

1.  Ny two right lines crossing one another, make the contrary or verticall angles equall.
2. If any right line fall upon two parallel right lines, it maketh the outward angles on the one, equall to the inward angles on the other, and the two inward opposite angles on contrary sides of the falling line also equall.
3. If any side of a Triangle be produced, the outward angle is equall to the two inward opposite angles, and all the three angles of any Triangle are equall to two right angles.
4. In equiangled Triangles, all their sides are proportionall, as well such as contain the equall angles, as also the subtendent sides.
5. If any four Quantities be proportionall, the first multiplied in the fourth, produceth a Quantity equall to that which is made by multiplication of the second in the third.
6. In all right angled Triangles, the square of the side subtending the right angle, is equall to both the squares of the containing sides.
7. All parallelograms are double to the triangles that are described upon their bases, their altitudes being equall.
8. All triangles that have one and the same Base, and lie between two parallel lines, are equall one to the other.

GE



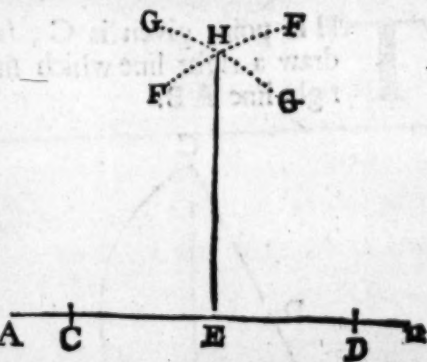
GEOMETRICALL PROBLEMES.

PROBLEME I.

Upon a right line given, how to erect another right line, which shall be perpendicular to the right line given.

THe right line given is A B, upon which from the point E it is required to erect the perpendicular E H.

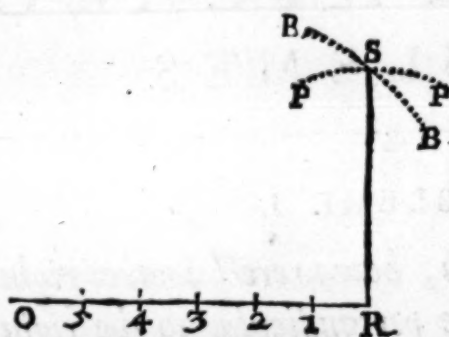
Opening your Compasses at pleasure to any convenient distance, place one foot in the assigned point E, and with the other make the marks C and D, equidistant on each side the given point E. Then opening your Compasses again to any other convenient distance wider then the former, place one foot in C, and with the other describe the arch G G, also (the Compasses remaining at the same distance) place one foot in the point D, and with the other describe the arch F F, then from the point where these two arches intersect or cut each other (which is at H) draw the right line H E which shall be perpendicular to the given right line A B, which was the thing required to be done.



PROB. II.

How to erect a Perpendicular on the end of a right line given.

LET OR be a line given, and let it be required to erect the perpendicular RS . First, upon the line OR , with your Compasses opened to any small distance, make five small divisions beginning at R , noted with 1, 2, 3, 4, 5. Then take with

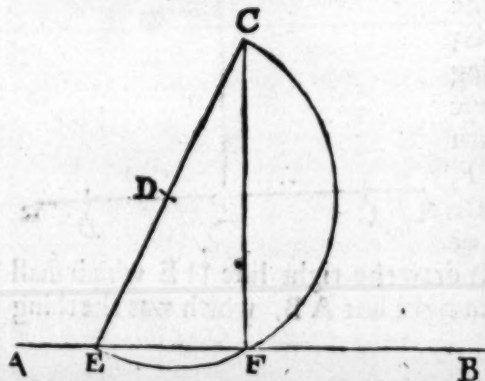


your Compasses the distance from R to 4, and placing one foot in R , with the other describe the arch PP . Then take the distance $R5$, and placing one foot of the Compasses in 3, with the other foot describe the arch BB , cutting the former arch in the point S . Lastly, from the point S , draw the line RS , which shall be perpendicular to the given line OR .

PROB. III.

How to let fall a perpendicular, from any point asigned, upon a right line given.

THE point given is C , from which point it is required to draw a right line which shall be perpendicular to the given right line AB .



First, from the given point C , to the line AB , draw a line by chance, as CE , which divide into two equall parts in the point D , then placing one foot of the Compasses in the point D , with the distance DC , describe the Semicircle CFE , cutting the given line AB in the point F . Lastly, if from the point C you draw the right line CF , it shall be a perpendicular to the given line AB , which was required.

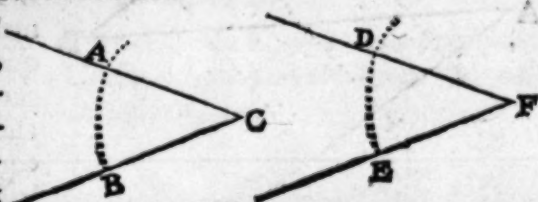
PROB.

PROB. IV.

How to make an angle equall to an angle given.

L Et the angle given be ACB , and let it be required to make another angle equall thereunto.

First, draw the line EF at pleasure, then upon the given angle at C , (the Compasses opened to any distance) describe the ark



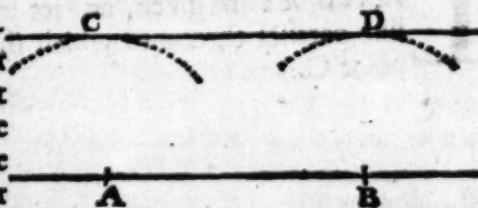
AB , also, upon the point F (the Compasses un-altered) describe the arke DE : then take with your Compasses the distance AB , and set the same distance from E to D . Lastly, draw the line DF , so shall the angle DFE be equall to the given angle ACB .

PROB. V.

A right line being given, how to draw another right line which shall be parallel to the former, at any distance required.

T He line given is AB , unto which it is required to draw another right line parallel thereunto, at the distance AC , or BD .

First, Open your Compasses to the distance AC or AD , then placing one foot in A , with the other describe the arke C ; also, place one foot in B , and with the other describe the arch D . Lastly,



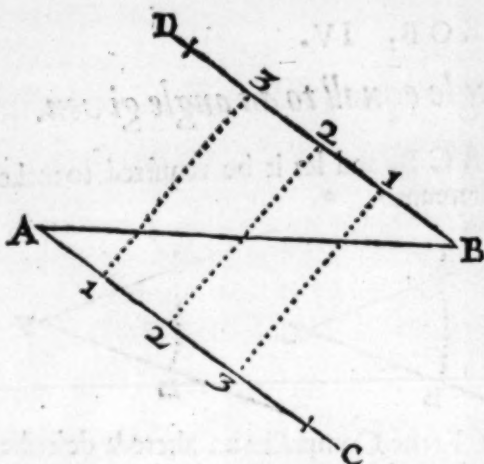
Draw the line CD so that it may only touch the arks C and D , so shall the line CD be parallel to the line AB , and at the distance required.

PROB. VI.

To divide a right line given into any number of equall parts.

L Et AB be a line given, and let it be required to divide the same into four equall parts.

First,



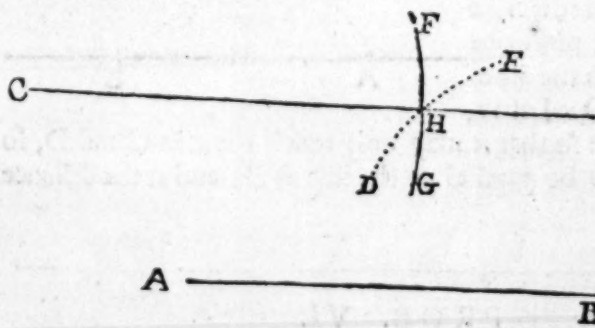
First, From the end of the given line A, draw the line AC, making any angle, then from the other end of the given line, which is at the point B, draw the line BD parallel to AC, or make the angle ABD equall to the angle CAB, then upon the lines AC and BD set off any three equall parts (which is one lesse then the number of parts into which the line AB is to be divided) on

each line, as 1 2 3, then draw lines from 1 to 3, from 2 to 2, and from 3 to 1, which lines, crossing the given line AB, shall divide it into four equall parts as was required.

PROB. VII.

A right line being given, how to draw another right line parallel thereunto, which shall also passe through a point assigned.

Let AB be a line given, and let it be required to draw another line parallel thereunto which shall passe through the given point C.



First, Take with your compasses the distance from A to C, and placing one foot thereof in B, with the other describe the ark DE, then take in your compasses the whole

line AB, and placing one foot in the point C, with the other describe the ark FG, crossing the former ark DE in the point H. Lastly, if you draw the line CH it shall be parallel to AB.

PROB.

PROB. VIII.

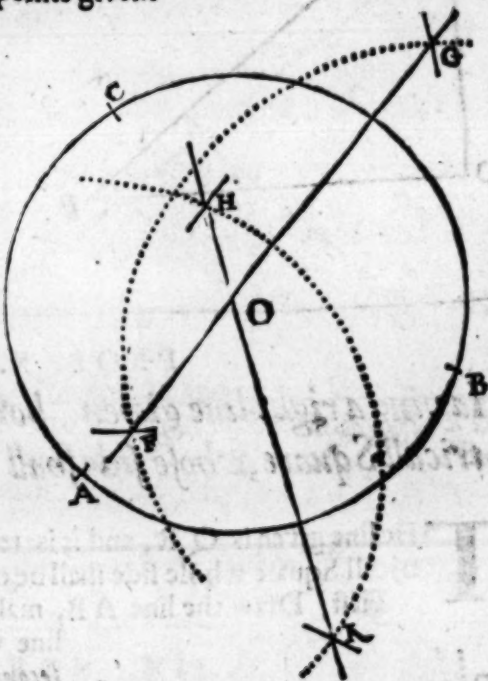
Having any three points given, which are not situate in a right line, how to finde the center of an arch of a Circle which shall passe directly through the three given points.

THe three points given are A B and C, now it is required to finde the center of a Circle, whose circumference shall passe through the three points given.

First, Opening your Compasses to any distance greater then halfe B C, place one foot in the point B, and with the other describe the arch F G, then, the Compasses remaining at the same distance, place one foot in C, and with the other turned about make the marks F and G in the former arch, and draw the line F G at length if need be.

Again, opening the Compasses to any distance greater then halfe A B, place one foot in the point A, and with the other describe the arch H K, then, the Compasses remaining at the same distance, place one foot in the point B, and turning the other about make the marks H K in the former arch.

Lastly, draw the right line H K cutting the line F G in O, so shall O be the center upon which if you describe a Circle at the distance of O A, it shall passe directly through the three given points A B C, which was required.

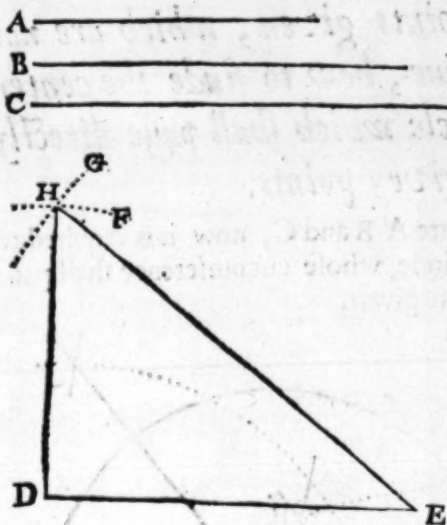


PROB. IX.

Any three right lines being given, so that the two shortest together be longer then the third, to make thereof a Triangle.

Let it be required to make a Triangle of the three lines A B and C, the two shortest whereof, viz. A and B together, are longer then the third line C.

First,



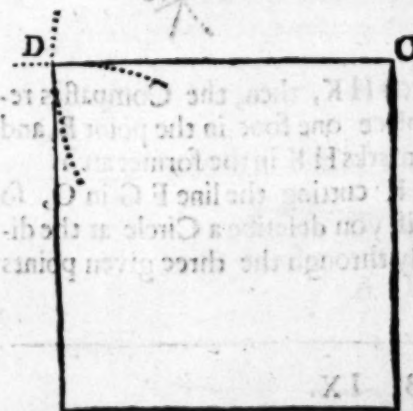
First, Draw the line D E equall to the given line B, then take with your Compasses the line C, and setting one foot in E, with the other describe the arch H G, also, take the given line A in your Compasses, and placing one foot in D, with the other describe the arch H F, cutting the former arch H G in the point H. Lastly, if from the point H you draw the lines H E and H D, you shall constitute the Triangle H D E, whose sides shall be equall to the three given lines A B C.

PROB. X.

Having a right line given, how to make a Geometrical Square, whose side shall be equall therunto.

The line given is Q R, and it is required to make a Geometrical Square whole side shall be equall to the line Q R.

First, Draw the line A B, making it equall to the given line Q R, then (by the first or second Probleme) upon the point B raise the perpendicular B C,



making the line B C equall to the given line Q R also. Then taking the line Q R in your Compasses, place one foot in C, and with the other describe the arch D, also the Compasses so resting, place one foot in A, and with the other describe another arch crossing the former in the point D. Lastly, draw the lines D C and D A, which shall include the Geometrical Square A B C D.

PROB.

PROB. XI.

Two right lines being given, how to finde a third right line which shall be in proportion unto them.

Let the two given lines be A and B, and let it be required to finde a third line which shall be in proportion unto them.

First, Draw two right lines making any angle at pleasure, as the lines O P and O N, making the angle P O N, then taking the line A in your Compasses, set the length thereof from O to S,

also, take the line B in your Compasses, and set the length thereof from O to R, and also from O to D, then draw the right line S D, and from the point R draw the line R C parallel to S D, so shall O C be the third proportionall required, for,

$$\begin{array}{ccccccc} \text{As OS to OD} & :: & \text{so OR to OC.} \\ 8 & 12 & 12 & 18. \end{array}$$

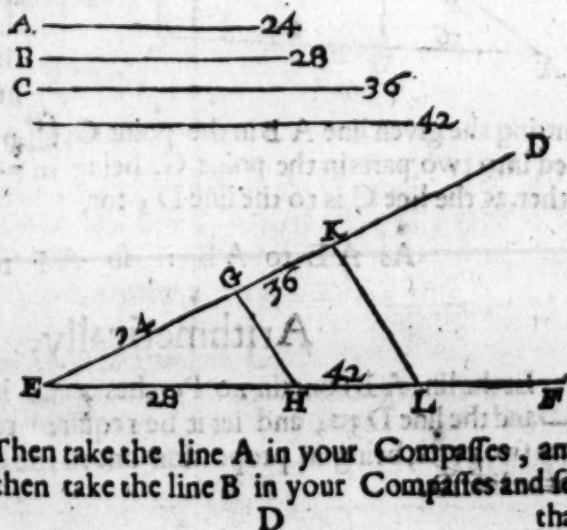
PROB. XII.

Three right lines being given, to finde a fourth in proportion to them.

The three lines given are A B C. unto which it is required to finde a fourth proportionall line. This is to perform the rule of three in lines.

As in the last Problem, you must draw two lines making any angle, as the angle D E F.

Then take the line A in your Compasses, and set it from E to G, then take the line B in your Compasses and set that



that length from E to H. Then take the third given line in your Compasses, and set that from E to K, and through that point K draw the line K L parallel to G H, so shall the lisse E L be the third proportionall required; for,

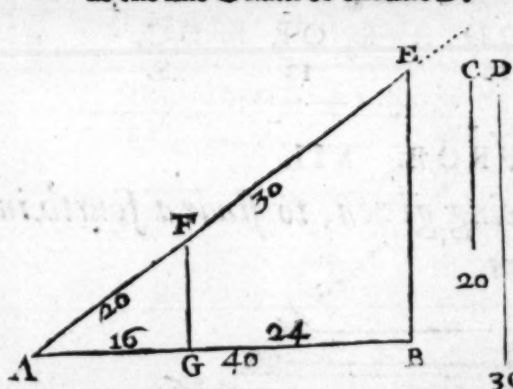
$$\begin{array}{cccc} \text{As EG to EH} & :: & \text{so EK to EL.} \\ 24 & 28 & 36 & 42. \end{array}$$

Here note that in the performance of this Probleme, that the first and the third termes (namely the lines A and C) must be set upon one and the same line, as here upon the line ED, and the second term (namely the line B) must be set upon the other line E F, upon which line also the fourth proportional E L will be found.

PROB. XIII.

To divide a right line given into two parts, which shall have such proportion one to the other as two given right lines.

The line given is A B, and it is required to divide the same into two parts, which shall have such proportion one to the other, as the line C hath to the line D.



First, from the point A, draw the line A E, at pleasure, making the angle E A B; then take in your Compasses the line C, and set it from A to F, also take the line D, and set it from F to E, and draw the line E B, then from the point F, draw the line F G parallel to E B, cutting the given line A B in the point G; so is the line A B divided into two parts in the point G, being in proportion one to the other, as the line C is to the line D; for,

$$\text{As AE to AB} :: \text{so AF to AG.}$$

Arithmetically.

Let the line A B contain 40 Perches, and let the line C be 20, and the line D 30, and let it be required to divide the line A B into two parts, being in proportion one to the other, as the line C is to the line D.

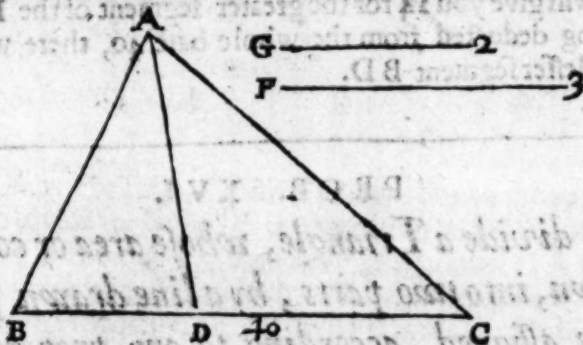
First, Adde the lines C and D together, their summe is 50, then say by the Rule of Proportion: If 50 (which is the summe of the two given terms) give 40 the whole line A B, what shall 30, the greater given term give? Multiply and divide, and you shall have in the quotient 24 for the greater part of the line A B, which being taken from 40 the whole line, there remains 16 for the other part A G, for,

$$\begin{array}{cccc} \text{As AE to AB} & :: & \text{so FE to GB.} \\ 50 & 40 & 30 & 24. \end{array}$$

PROB. XIV.

How to divide a Triangle into two parts, according to any proportion assigned, by a line drawn from any angle thereof, and to lay the lesser part towards any side assigned.

L Et A B C be a Triangle given, and let it be required to divide the same, by a line drawn from the angle A, into two parts, the one bearing proportion to the other, as the line F doth to the line G, and that the lesser part may be towards the side A B.



By the last *Probleme* divide the base of the Triangle B C in the point D, in proportion as the line F is to the line G, (the lesser part being set from B to D.) Lastly, draw the line A D, which shall divide the Triangle A B C in proportion as F to G, for,

As the line F, is to the line G,

So is the Triangle A D C, to the Triangle A B D.

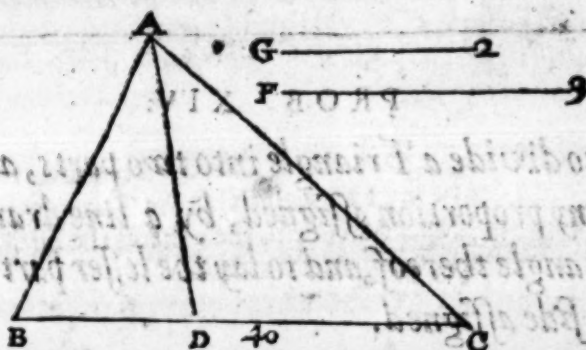
D 2

PROB.

PROB. XV.

The Base of the Triangle being known, to perform the foregoing Probleme by Arithmetick.

Suppose the Base of the Triangle BC to be 40, and let the proportion into which the Triangle ABC is to be divided, be as 2 to 3.



First, Add the two proportionall terms together, 2 and 3, which makes 5, then say by the rule of proportion: If 5 (the sum of the proportionall terms,) give 40 (the whole base BC ;) what shall 3 (the greater term) give? Multiply and divide, and the quotient will give you 24 for the greater segment of the Base DC , which being deducted from the whole base 40, there will remain 16 for the lesser segment BD .

PROB. XVI.

How to divide a Triangle, whose area or content is known, into two parts, by a line drawn from an angle assigned, according to any proportion required.

Let the Triangle ABC contain 8 Acres, and let it be required to divide the same into two parts, by a line drawn from the angle A , the one to contain 5 Acres, and the other 3 Acres.

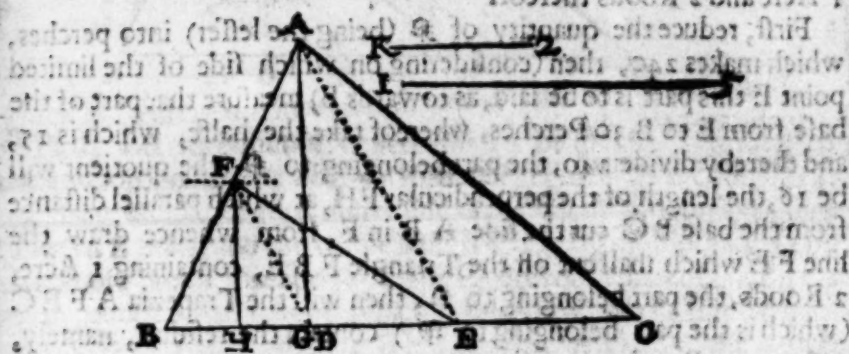
First, Measure the whole length of the Base, which suppose 40, then say, If 8 Acres (the quantity of the whole Triangle) give 40, (the whole Base,) what parts of the Base shall 5 Acres give? Multiply and divide, the Quotient will be 25 for the greater segment of the base CD , which being deducted from 40 (the whole Base,) there will remain 15 for the lesser segment of the Base BD , then draw

draw the line AD , which shall divide the Triangle ABC according to the proportion required.

PROB. XVII.

How to divide a Triangle given into two parts, according to any proportion assigned by a line drawn from a point limited in any of the sides thereof: and to lay the greater or lesser part towards an angle assigned.

The Triangle given is ABC and it is required from the point E , to draw a line that shall divide the Triangle into two parts, being in proportion one to the other as the line I is to the line K , and to lay the lesser part towards B .



First, From the limited point E , draw a line to the opposite angle at A , then divide the base BC in proportion as I to K , which point of division will be at D , then draw DF parallel to AE . Lastly, from F , draw the line FE , which will divide the Triangle into two parts being in proportion one to the other as the line I is to the line K .

PROB. XVIII.

To perform the foregoing Problem Arithmetically.

It is required to divide the Triangle ABC , from the point E , into two parts in proportion as 5 to 2 .

First, Divide the base BC according to the given proportion, then (because the lesser part is to be laid towards B) measure the distance from E to B , which admit 30 , then say by the rule of Proportion, If EB 30 , give DB 15 , what shall AG 25 (the perpendicular of the Triangle) give? Multiply and divide, the Quotient will be

be 14, at which distance draw a parallel line to BC , namely EF , then from F draw the line FE , which shall divide the Triangle according to the required proportion.

PROB. XIX. *How to divide a Triangle, whose area or content is known, into two parts, by a line drawn from a point limited in any side thereof, according to any number of Acres, Roods and Perches.*

IN the foregoing Triangle ABC , whose area or content is 5 Acres, 1 Rood, let the limited point be E in the base thereof, and let it be required from the point E to draw a right line which shall divide the Triangle into two parts between M and P , so that M may have 3 Acres, 3 Roods thereof, and P may have 1 Acre and 2 Roods thereof.

First, reduce the quantity of P (being the lesser) into perches, which makes 240, then (considering on which side of the limited point E this part is to be laid, as towards B) measure that part of the base from E to B 30 Perches, whereof take the halfe, which is 15, and thereby divide 240, the part belonging to P , the quotient will be 16, the length of the perpendicular FH , at which parallel distance from the base BC cut the side AB in F , from whence draw the line FE which shall cut off the Triangle FBE , containing 1 Acre, 2 Roods, the part belonging to P , then will the Trapezia $A FEC$ (which is the part belonging to M) contain the residue, namely, 3 Acres, 3 Roods.

PROB. XX. *How to divide a Triangle according to any proportion given, by a line drawn parallel to one of the sides.*

The following Triangle ABC is given, and it is required to divide the same into two parts by a line drawn parallel to the side AC , which shall be in proportion one to the other, as the line I is to the line K .

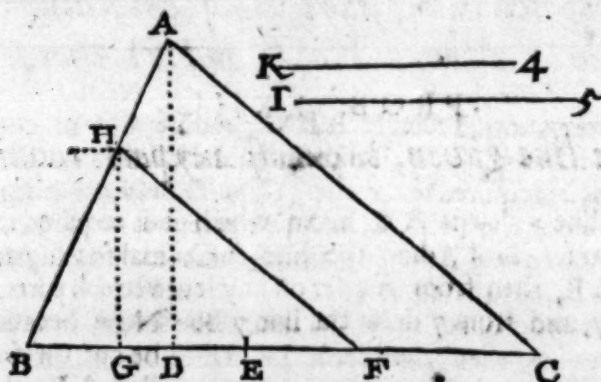
First (by the 13 Probleme) divide the line BC in E , in proportion as I to K , then (by the 24 Probleme following) finde a mean proportionall between BE and BC , which let be BF , from which point F , draw the line FH parallel to AC , which line shall divide the Triangle into two parts, viz, the Trapezia $AHFC$, and the Triangle

Triangle HFB, which are in proportion one to the other as the line I is to the line K.

PROB. XXI.

To perform the foregoing Probleme Arithmetically.

Let the Triangle be ABC, and let it be required to divide the same into two parts, which shall be in proportion one to the other, as 4 to 5, by a line drawn parallel to one of the sides.



First, Let the base BC containing 54 be divided according to the proportion given, so shall the lesser segment BE contain 24, and the greater EC 30, then finde out a mean proportionall line between BE 24, and the whole base BC 54, by multiplying 54 by 24, whose product will be 1296, the square root whereof is 36, the mean proportionall sought, which is BF, then, by the rule of proportion say: If BF 36, give BE 24, what AD 36? the answer is HG 24, at which distance draw a parallel line to the base, to cut the side AB in H, from whence draw the line HF parallel to AC, which shall divide the Triangle as was required.

PROB. XXII.

To divide a Triangle of any known quantity, into two parts, by a line drawn parallel to one of the sides, according to any number of Acres, Roods, and Perches.

The Triangle given is ABC, whose quantity is 8 Acres, 0 Roods, 16 Perches, and it is required to divide the same (by a line drawn parallel to the side AC) into two parts, viz. 4 Acres, 2 Roods, 0 Perches, and 3 Acres, 2 Roods, 16 Perches.

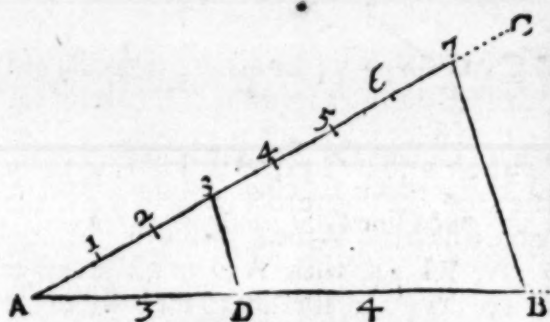
First,

First, Reduce both quantities into perches (as is hereafter taught) and they will be 720, and 576, then reduce both those numbers, by abbreviation, into the least proportionall terms, viz. 5 and 4, and according to that proportion, divide the base BC of the given Triangle in E , then seeke the mean proportionall between BE and BC , which proportionall is BF 36, of which 36 take the halfe, and thereby divide 576, the lesser quantity of Perches, the Quotient will be HG 32, at which parallel distance from the base, cut off the line AB in H , from whence draw the line HF parallel to the side AC , which shall divide the Triangle given according as was required.

PROB. XXIII.

From a line given, to cut off any parts required.

THe line given is AB , from which it is required to cut off $\frac{1}{3}$ parts. First, draw the line AC , making any angle, as CAB , then from A , set off any seven equall parts, as 1 2 3 4 5 6 7, and from 7 draw the line 7 B . Now because $\frac{1}{3}$ is to



be cut off from the line AB , therefore from the point 3, draw the line 3 D parallel to 7 B , cutting the line AB in D , so shall AD be $\frac{1}{3}$ of the line AB , and DB shall be $\frac{2}{3}$ of the same line; for,

As $A7$, is to $AB :: 3$ is $A3$, to AD .

PROB. XXIV.

To finde a mean proportionall between two lines given.

IN the following figure, let the two lines given be A and B , between which it is required to finde a mean proportionall.

Let the two given lines A and B , be joynd together in the point E , making one right line, as CD , which divide into two equall parts in the point G , upon which point G , with the distance GC or GD , describe the Semicircle CFD ; then, from the point E , (where the two lines are joynd together) raise the perpendicular EF , cutting the Periferie of the Semicircle in F , so shall the line EF

EF be a mean proportionall between the two given lines A and B, for,

$$\text{As } ED \text{ to } EF :: \text{so } EF \text{ to } CE.$$

9

12

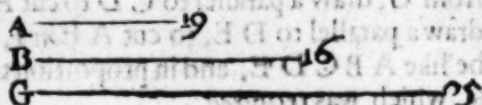
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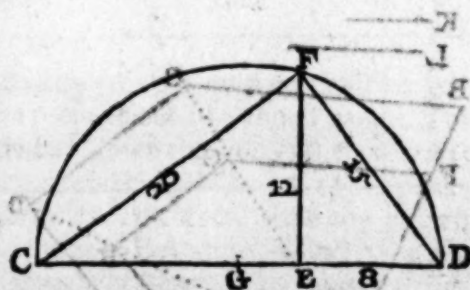
PROB. XXV.

How to divide a line in power according to any proportion given.

IN this figure let CD



be a line given to be divided in power as the line A is to the line B. First, divide the line C D in the point E, in proportion as A to B, (by the 13. Problems :) then divide the line C D into two equal parts in the point G, and on G, at the distance G C or G D, describe the Semicircle C F D, and upon the point E,



raise the perpendicular EF, cutting the Semicircle in F: Lastly, draw the lines CF and DF, which together in power shall be equal to the power of the given line CD, and yet in power one to the other as A to B.

PROB. XXVI.

How to enlarge a line in power, according to any proportion assigned.

IN the former figure, Let CE be a line given, to be enlarged in power as the line B to the line G.

First, (by the 13. Problems) find a line in proportion to the given line CE, as B is to G, which will be CD, upon which line describe the Semicircle C F D, and on the point E, erect the perpendicular EF, then draw the line CF, which shall be in power to CE, as G to B.

E

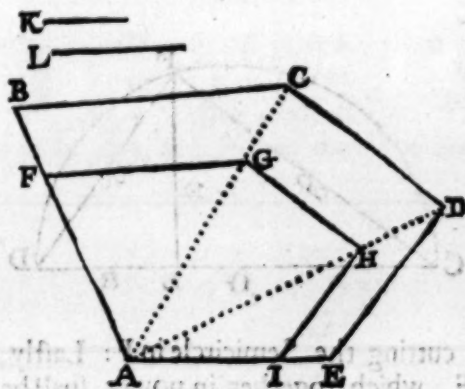
PROB.

PROB. XXVII.

To enlarge or diminish a Plot given, according to any proportion required.

L Et A B C D E be a Plot given, to be diminished in power as L to K.

Divide one of the sides (as A B) in power as L to K, in such sort, that the power of A F, may be to the power of A B, as L to K. Then from the angle A, draw lines to the points C and D, that done, by F draw a parallel to B C, to cut A C in G, as F G. Again, from G, draw a parallel to C D to cut A D in H. Lastly, from H, draw a parallel to D E, to cut A E in I, so shall the plot A F G H I be like A B C D E, and in proportion to it, as the line L, to the line K, which was required.



Also, if the lesser Plot were given, and it were required to make a greater in proportion to it as K to L. Then from the point A, draw the lines A C and A D, at length, also increase A F and A I: that done, enlarge A F in power as K to L, which set from A to B, then by B draw a parallel to F G to cut A C in C, as B C. Likewise from C draw a parallel to G H, to cut A D in D, as C D. Lastly, a parallel from D to H I, as D E, to cut A I being increased in E, so shall you include the Plot A B C D E, like A F G H I, and in proportion thereunto, as the line K is to the line L, which was required.

PROB. XXVIII.

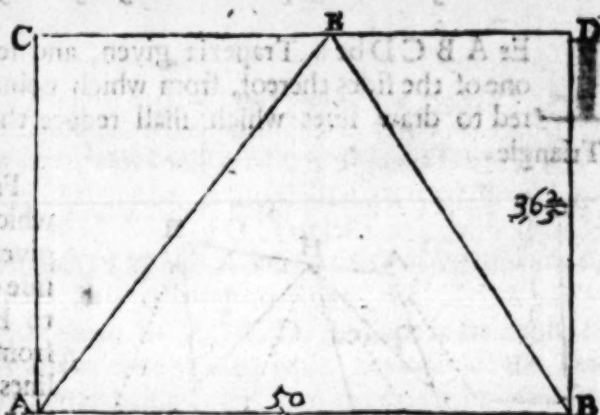
How to make a Triangle which shall contain any number of Acres, Roods and Perches, and whose base shall be equal to any possible number given.

I f it be required to make a Triangle which shall contain 5 Acres, 1 Rood, 30 Perches, whose base shall contain 50 Perches, you must first reduce your 5 Acres, 2 Roods, 30 Perches, all into Perches in this manner.

First, (because 4 Roods make one Acre) multiply your 5 Acres by 4 which makes 20, to which adde the two odde Roods, so have you

you 22 Roods in your 5 Acres 2 Roods. Then (because 40 Perches make one Rood) multiply your 22 Roods by 40, which makes 880 Perches, to which adde the 30 odde Perches, and you shall have 910, and so many Perches are contained in 5 Acres, 2 Roods, 30 Perches.

Now to make a Triangle which shall contain 910 perches, & whose base shall be 50 Perches, do thus, Double the number of perches given, namely 910, and they make 1820, then because the base of the triangle must



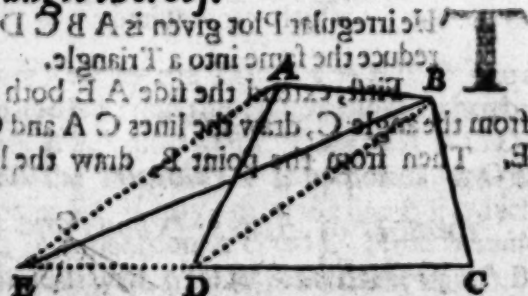
contain 50 Perches, divide 1820 by 50, the quotient will be 36 $\frac{1}{2}$, which will be the length of the perpendicular of your Triangle. This done, From any equal Scale lay down the line AB equal to 50 Perches, then upon B, raise the perpendicular BD equal to 36 $\frac{1}{2}$ perches, and draw the line CD parallel to AB: then, from any point in the line CD (as from E) draw the lines EA and EB, including the Triangle AEB, which shall contain 5 Acres, 2 Roods, 30 Perches, which was required.

PROB. XXIX.

How to reduce a Trapezia into a Triangle, by a line drawn from any angle thereof.

The Trapezia given is ABCD, and it is required to reduce the same into a Triangle.

First, Extend the line DC, and draw the Diagonall BD, then from the point A, draw the line AE parallel to BD, extending it till it cut the side CD in the point E. Lastly, from B, draw the line BE, constituting the Triangle EBC, which shall be equal to the Trapezia ABCD.



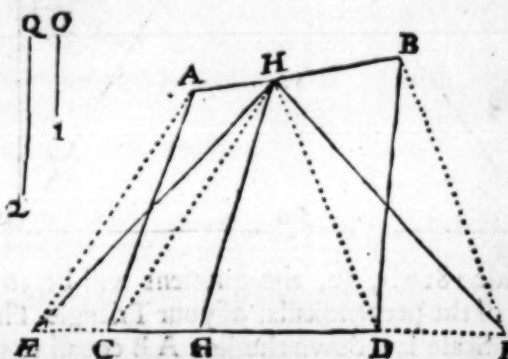
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PROB.

PROB. XXX.

How to reduce a Trapezia into a Triangle, by lines drawn from any point in any of the sides thereof.

Let $ABCD$ be a Trapezia given, and let H be a point in one of the sides thereof, from which point H let it be required to draw lines which shall reduce the Trapezia into a Triangle.



First, Extend the side which is opposite to the given point, namely, the side CD , both ways to E and F , and then from the point H , draw lines to the angles C and D , as the lines HC and HD ; also, draw the lines AE and BF parallel to HC and HD , cutting the extend-

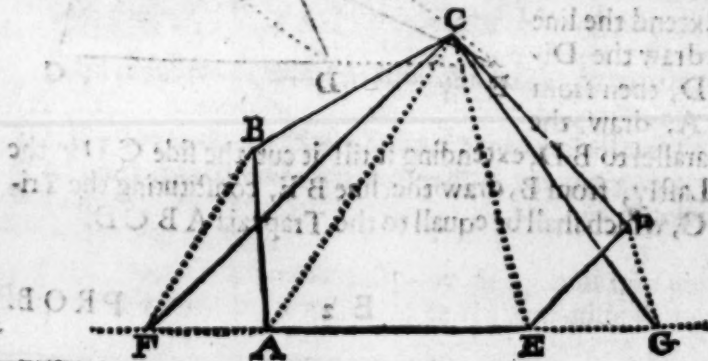
ed line CD in the points E and F . Lastly, If from the point H you draw the lines HE and HF , you shall constitute the Triangle HEF , which shall be equal to the Trapezia $ABCD$.

PROB. XXXI.

How to reduce an irregular Plot of five sides into a Triangle.

The irregular Plot given is $ABCDE$, and it is required to reduce the same into a Triangle.

First, extend the side AE both ways to F and G , and from the angle C , draw the lines CA and CE , to the angles A and E . Then from the point B , draw the line BF parallel to CA



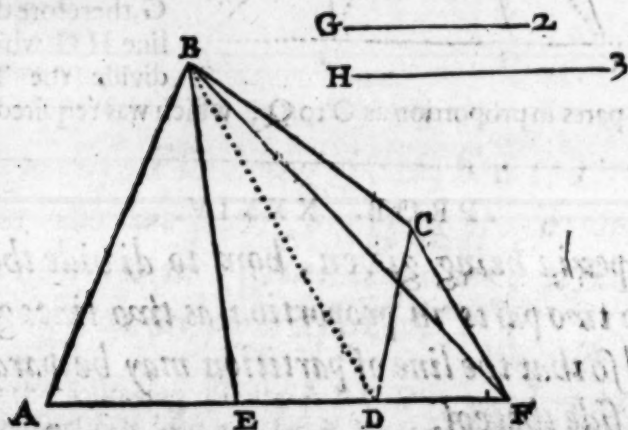
cutting

cutting the extended side AE , in F ; also, from the point D , draw the line DG parallel to CE , cutting also the extended side in G . Lastly, from the angle C , draw the lines CF and CG , constituting the Triangle CFG which is equal to the Plot $ABCD$.

PROB. XXXII.

A Trapezia being given, how from any angle thereof to divide the same into two parts being in proportion one to the other as two given right lines, and to set the part cut off towards an assigned side.

Let the Trapezia given be $ABCD$, and let it be required to draw a line from the angle B , which shall divide the Trapezia into two parts, being in proportion one to the other, as the line G is to the line H , and that the lesser part of the Figure cut off, may be towards the side AB .

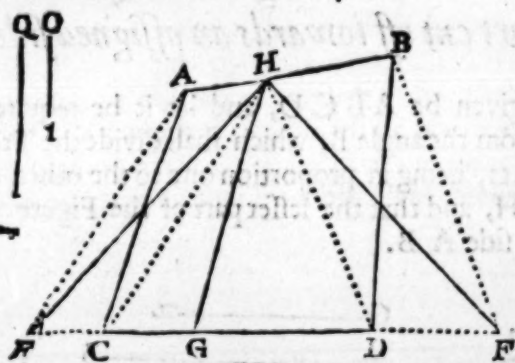


First (by the 29 Problem) reduce the Trapezia $ABCD$ into a Triangle, by drawing the line BF from the assigned angle, thereby constituting the Triangle ABF , equal to the Trapezia $ABCD$: this done, divide the base of the Triangle AF in proportion as G to H , which will be in the point E . Lastly, draw the line BE , which shall divide the Trapezia in proportion as G to H . Now because the lesser part of the Trapezia was to be set towards the side AB , therefore the lesser part of the line must be set from A to E . Here note that the same manner of working is to be observed, if it had been required to divide the Trapezia by a line drawn from any of the other angles.

PROB. XXXIII.

A Trapezia being given, how, from a point limited in any side thereof, to draw a line which shall divide the same into two parts in proportion as two given lines.

The Trapezia given is $A B C D$, and it is required from the point H , to draw a line which shall divide the Trapezia in proportion as O to Q .



First, Prolong the side $C D$. and reduce the whole Trapezia into the Triangle $H E F$ by the 30 *Probleme*, then divide the line $E F$ in proportion as O to Q , which will fall in the point G , therefore draw the line $H G$ which shall divide the Trapezia

into two parts in proportion as O to Q , which was required,

PROB. XXXIV.

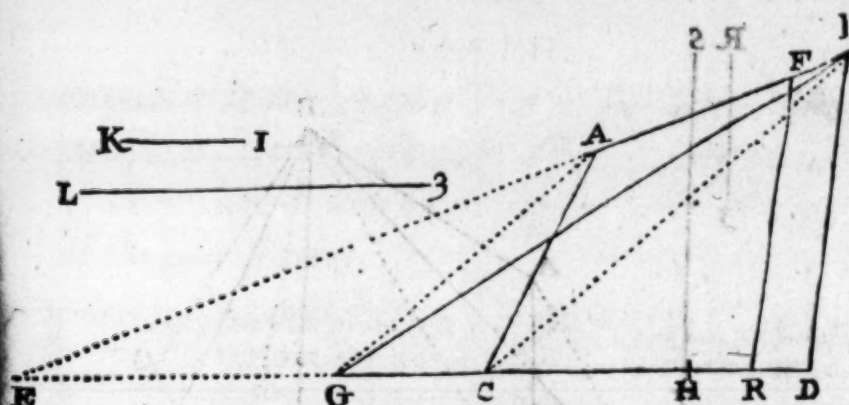
A Trapezia being given, how to divide the same into two parts in proportion as two lines given, and so that the line of partition may be parallel to any side thereof.

The Trapezia given is $A B C D$, and it is required to divide the same into two parts, which shall be in proportion one to the other as the line K is to the line L , and that the line of partition may be parallel to the side $B D$.

Consider first, through which sides of the Trapezia the line of partition will passe, as in this Figure it will passe through the sides $A B$ and $C D$ (because parallel to $B D$), therefore, extend the sides $A B$ and $C D$, till they concur in E , then (by the 32 *Probleme*) reduce the Trapezia $A B C D$ into the Triangle $B E D$, whose base is $G D$, which line $G D$, divide in the point H in proportion as K to L , so that,

As K to L :: So DH to HG .

This



This done, finde a mean proportionall between ED and EH (by the 24 Probleme) as ER . Lastly, through this point R , draw the line RF parallel to BD , which shall divide the Trapezia into two parts being in proportion one to the other, as the line K is to the line L , and with a line parallel to the side BD , which was required.

But if it had been required to divide the Trapezia by a line drawn parallel to the side CD , then the lines CA and DB must have been extended, but the rest of the work must be performed as is before taught.

PROB. XXXV.

The figure of a Plot being given, how to divide the same into two parts, being in proportion one to the other as two given lines are, with a line drawn from an angle assigned.

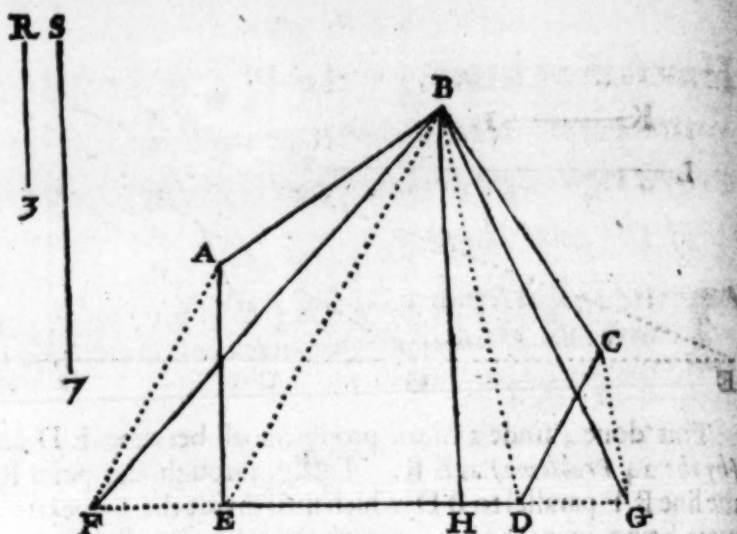
Let the following Figure $ABCDE$ represent the Plot of a Field or such like, and let it be required to divide the same into two parts, being in proportion one to the other as the line R is to the line S , by a line drawn from the angle B .

First, Reduce the Plot $ABCDE$ into the Triangle BFG , (by the 31 Probleme) so shall the line FG be the base of a Triangle equall to the given Plot, then (by the 13 Probleme) divide this line FG into two parts in the point H , in proportion one to the other, as the line R is to the line S , so that,

$$\text{As } R \text{ to } S :: \text{so } GH \text{ to } HF.$$

Lastly, draw the line BH , which shall divide your given Plot into two parts which shall have such proportion one to the other, as the line R hath to the line S .

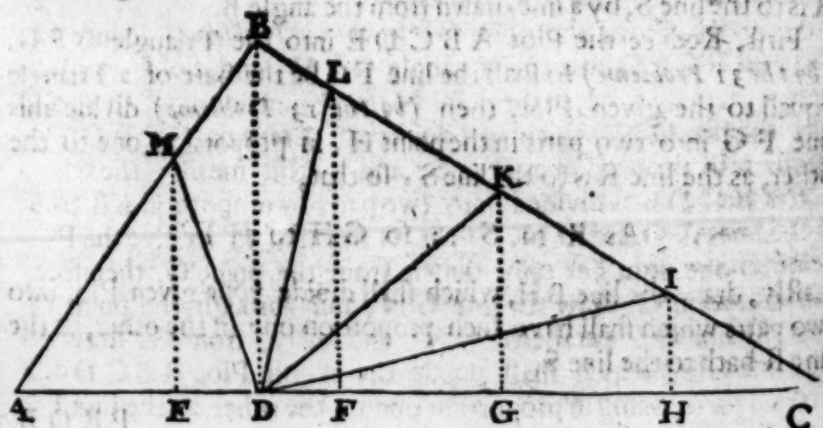
PROB.



PROB. XXXVI.

How to divide a Triangle into any number of equal parts, by lines drawn from a point given in any side thereof.

L Et it be required to dividethe Triangle A B C into five equal parts, by lines drawn from the point D.
 First, From the given point D, to the opposite angle B, draw the line D B, then divide the side A C of the Triangle into five equal parts, at E F G and H, and through each of those points draw lines parallel to D B, as E M, F L, G K, and H I: then from the point D, draw the lines D I, D K, D L, and D M, which shall divide the Triangle A B C into five equal parts from the point D, as was required.

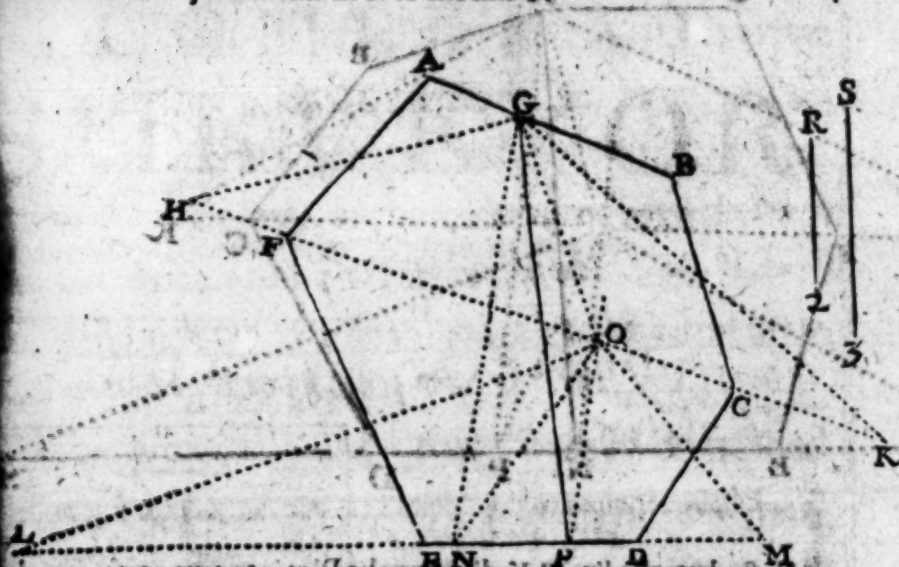


PROB.

PROB. XXXVII.

How to divide an irregular Plot of six sides, into two parts, according to any assigned proportion, by a right line drawn from a point limited in any of the sides thereof.

The irregular Plot given is $ABCDEF$, and it is required to divide the same into two parts, being in proportion one to the other, as the line R is to the line S .



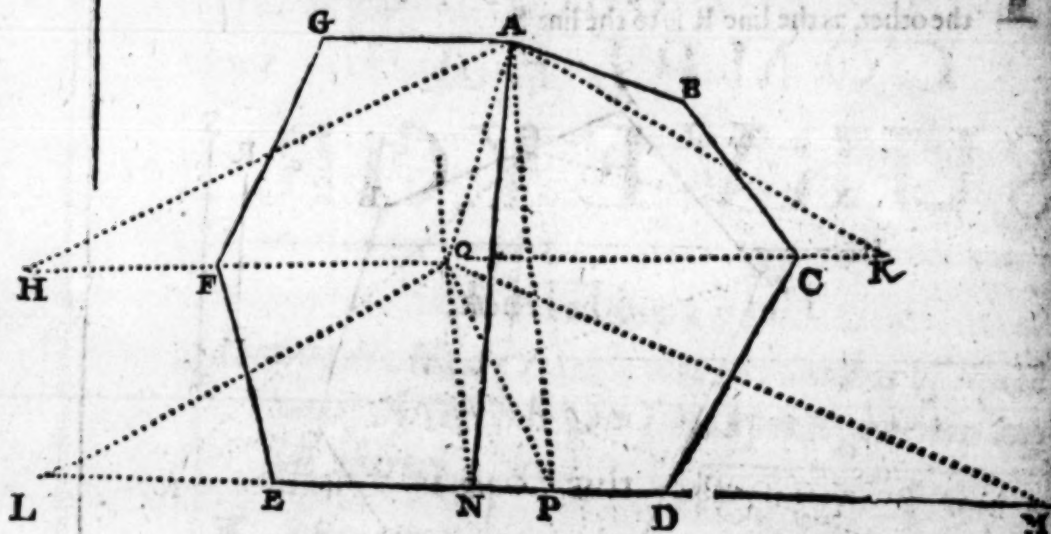
First, Draw the right line HK , and (by the 30 Problem) reduce the Trapezia $ABFG$ into the Triangle HGK , then divide the base thereof, namely HK , into two parts in proportion as R to S , which will be in the point O , then draw the line GO , which will divide the Trapezia $ABFC$ into two parts in proportion one to the other, as the line R is to the line S .

Secondly, From the point O (by the 31 Problem) reduce the Trapezia $FCED$ into the Triangle OLM , and divide the base thereof, namely LM , in the point N , in proportion as R to S , and draw the line ON , which will divide the Trapezia $FCED$ into two parts in proportion as R to S ; and by this means is the whole Plot $ABCDEF$ divided into two parts in proportion as R to S , by the lines GO and ON . But it is required to resolve the Problem by one right line only drawn from the point G , therefore, from the point G , draw the line GN , and through the point O , draw the line OP parallel to GN : and lastly, from G , draw the right line GP , which shall divide the whole Plot $ABCDEF$ into two parts, being in proportion one to the other as the line T is to the line S .

PROB. XXXVIII.

How to divide an irregular Plot according to any proportion, by a line drawn from any angle thereof.

L Et ABCDEFG be an irregular Plot, and let it be required to divide the same into two equal parts, by a line drawn from the angle A.



First, draw the line HK, dividing the Plot into two parts, namely, into the five sided figure ABCFG, and into the Trapezia FCED, then (by the 31 Probleme) reduce the five sided figure ABCFG into the Triangle HAK, the base whereof HK divide into two equal parts in O, and draw the line OA, which shall divide the five sided figure ABCFG into two equal parts. Then (by the 30 Probleme) reduce the Trapezia FCDE into the Triangle OLM, and divide the base thereof LM into two equal parts in the point P, and draw the line OP, which will divide the Trapezia FCDE into two equal parts, and so is the whole Plot divided into two equal parts by the lines AQ and OP, but to performe the Probleme by one right line only, do thus, from the point A, draw the line AP, and parallel therunto, through the point O, draw the line ON. Lastly, if you draw a right line from A to N, it shall divide the whole Plot into two equal parts.

The end of the First Book.



ther; so that whatsoever may be done by the
 Theodolite, Circumferentor, or any other Instru-
 ment, the same may be effected by the
COMPLEAT SURVEYOR.

The Second Book.

THE ARGUMENT.

IN this Book is contained
 both a generall and par-
 ticular description of all
 the most necessary Instru-
 ments belonging to Sur-
 veying, as the Theodolite,
 Circumferentor and Plain

Table, with all the appurtenances thereunto be-
 longing, as the Staffe, Sockets, Screws, Index,
 Label, and other necessities. Now whereas
 these three Instruments are the most convenient
 for all manner of practises in Surveying, I have
 so ordered the matter, that in this Book, after

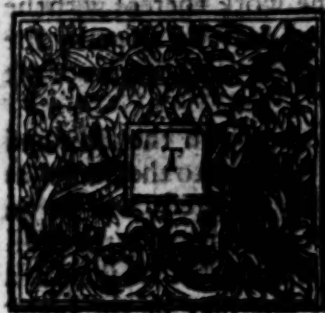
the *Theodolite* and *Circumferentor* are particularly described, as they have usually been made; I come to the description of the *Plain Table*, and therein have shewed how that *Instrument* may be ordered to performe the work of any of the other; so that whatsoever may be done by the *Theodolite*, *Circumferentor*, or any other *Instrument*, the same may be effected by the *Plain Table* onely, as it is there contrived, with the same ease, dispatch, and exactnesse, and in many respects better, as in *Chap. 1.* doth plainly appear: so that this *Instrument* onely is sufficient for all manner of practises whatsoever. And besides the fore-mentioned *Instruments* for mensuration there is described divers other *Instruments* belonging thereunto, as *Chains*, *Scales*, *Protractors*, and the like; all which are described according to the best contrivance yet known.

After this manner I have ordered the matter, that in this Book after the

DESCRIPTION OF INSTRUMENTS

CHAP. I.

Of Instruments in general



He particular description of the severall Instruments that have from time to time been invented for the practise of Surveying, would make a Treatise of it self, and in this place is not so necessary to be insisted on, every of the inventors, in their severall Books of the uses of them having been already large enough in their construction. To omit therefore the description of the Topographical Instru-

ment of Master Leonard Digges, the Familiar Staffe of Master John Blagrave, the Geodericall Staffe, and Topographical Glasse of Master Arthur Hopton, with divers other Instruments invented and published by Gemma Frisius, Orontius, Clavius, Steffern, and others, I shall immediately begin with the description of those which are the ground and foundation of all the rest, and are now the only Instruments in most esteem amongst Surveyors, and those are chiefly these three, the Theodolite, the Circumferentor, and the Plain Table. Now, as I would not confine any man to the use of one particular Instrument for all employments, so I would advise any man not to cumber himselfe with multiplicity, since these three last named are sufficient for all occasions. And if I should confine any man to the use of any one of these Instruments (as, for a shiffr, any one of them will perform any kinde of work in Surveying) yet in that I should do him injury, for in many cases one Instrument may make a quicker dispatch, and be altogether as exact as another: As in laying down of a spacious businesse, I would advise

wise him to use the Circumferentor or Theodolite, and for Townships and small Black Towns, the Plain Table, both which Instruments according to the manner of making of the ground, does to measure doth require.

These three Instruments have been already described already by others, as namely by Master Digges, Master Blount, Master Ratcliffe, and others, yet in this place it will be very necessary to give a particular description of them again, because if any man have a desire to any particular Instrument, he may give the better directions for the making thereof.

For the description which I shall make of these three Instruments in particular, it shall be agreeable to those Instruments as they are usually made, with some small addition or alteration: But when I come to the description of the Plain Table, after that I have described it according to the vulgar way, I will then shew you a new metamorphosis of that Instrument, making it the most absolute and universall Instrument yet ever invented, so that having that one Instrument (made according to the following directions) you shall have need of no other for the due, exact, and speedy performance of any thing belonging to the Art of Surveying. For, the Frame of the Table being graduated according to that description, will be an absolute Theodolite, and perform the work thereof with the same facility and exactness, and whatsoever may be done by the Limbe of the Theodolite, the same the degrees on the frame of the Table will as well perform.

The Plain Table used as the Theodolite.

The Plain Table used as a Circumferentor.

The plain Table, not one, but all Instruments.

Likewise, the Index and Sights, together with the Box and Needle, being taken from the Table, and forewed to the Staffe (as in the description thereof it is so conveniently ordered) will be an absolute Circumferentor, and in some respects better then the ordinary one hereafter described, because the Sights thereof stand at a greater distance, so that thereby the visual line may be the better directed.

And this Instrument (as now contrived) though it be called the Plain Table only, yet you see that it contains both the other, and therefore in advising any man to the use thereof chiefly, I do not confine him to one, but to all Instruments, and therefore do not contradict my former expression.

Besides, there is another great convenience which doth ensue by the degrees on the Table's frame; for, in taking the plot of a field according to the following directions by the Plain Table, you may at the same time perform the same work by the degrees on the frame of the Table, if at the drawing of every line you observe the degrees cut by the Index, and note them upon the paper. This I say is a great convenience, for at one observation you perform two works with the same labour, as in the uses of these Instruments severally will evidently appear. Many other conveniences will redound to a Surveyor by this contrivance, which with small practise will appear of themselves.

CHAP. II.

Of the Theodolite, the description thereof, and the detection of an error frequently committed in the making thereof, with the manner how to correct the same.



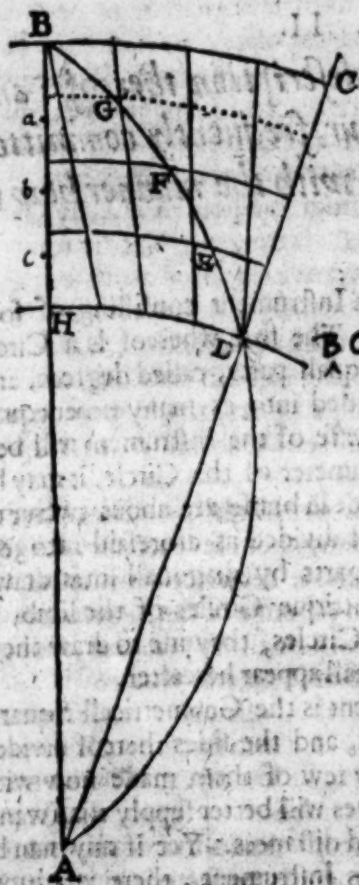
The Theodolite is an Instrument consisting of four parts principally. The first whereof is a Circle divided into 360 equall parts, called degrees, and each degree sub-divided into as many other equall parts as the largeness of the Instrument will best permit. For the diameter of this Circle, it may be of any length, but those usually made in brasse are about twelve or fourteen inches, and the limb thereof divided as aforesaid into 360 degrees, and sub-divided into other parts by diagonall lines drawn from the outmost and inmost concentric Circles of the limb, in the drawing of which concentric Circles, they use to draw them equidistant, which is erroneous, as shall appear hereafter.

The second part of this Instrument is the Geometricall Square, which is described within the Circle, and the sides thereof divided into certain equall parts, but there are few of them made now with this Square, for the degrees themselves will better supply that want, it being only for taking of heights and distances. Yet if any man be desirous to have this Square upon his Instrument, there is a more convenient way to set it on then that which Master Digges sheweth, namely, upon the limb of the Instrument, the manner how is well known to the Instrument maker.

The third part of this Instrument is the Box and Needle, so conveniently contrived to stand upon the center of the Circle, upon which center also the Index of the Instrument must turn about, and sometimes over the Box and Needle there is a Quadrant erected for the taking of heights and distances.

The fourth part of this Instrument is a Socket, to be screwed on the back side of the Instrument, to set it upon a staffe when you make use thereof. In the making of this Instrument, it were necessary to have two back Sights fixed at each end of one of the Diameters, for the readier laying out of any angle without moving of the Instrument.

Now, forasmuch as in the dividing of the Degrees of any Circumference (as of a Quadrant Theodolite, &c.) into Minutes, they usually draw the concentric Circles equidistant, which is false, as Master Norwood plainly demonstrereth, *pag. 51. Arithm. Flare Militari*, but because the way which he there sheweth is Trigonometricall, and sufficiently shewn by him, I will passe that by, and shew you another way how to perform the same Geometrically, as followeth.



Let the angle BAC be a part of the circumference of any Instrument, to be divided into four equall parts by Diagonals, and let it be required to finde where the concentric Circles E, F and G must be drawn, so that lines drawn from the center A through the points E, F and G , shall divide the arch BC into four equall parts. First, BD is the outward Circle of the limb of the Instrument, and HD the inward Circle, between which, the other three must be drawn concentricall (that is, upon the same center A) but not equidistant, therefore, (by the *Problem of the 1. Book*) draw the arch of a Circle which shall passe through the points B, D, A , then divide the part of that arch which lies between B and D into four equall parts in E, F and G , through which points draw the three Circles E, F and G , which shall be the true Circles that must crosse your Diagonals, to divide the limb into four equall parts, whereas, if the Circles had been equidistant, the arch would have been unequally divided, and this error is frequently practised, for in the making of any Instrument, they commonly divide the distance BH or CD into four equall parts, and through them draw the concentric Circles, whereas by the figure you see that the farther the Circles are from the center the closer they come together: but let this suffice for the correction of this Error.

CHAP. II.

The description of the Circumferentor.



His Instrument hath been much esteemed by many, for portability thereof, it being usually made to contain in length about eight inches, in breadth four inches, and in thickness about three quarters of an inch; one side whereof is divided into divers equall parts, most sily of ten or twelve in an inch, so that it may be used as the Scale of a Protractor, the Instrument it selfe being fitting to protract the

plat

Divisions should be
largest & farther they are
from y^e center viz. y^e
with E shall be in y^e
space of G , & G in E ,
which to do set one
point of y^e compasses
in E & take y^e nearest
distance to y^e Arch HD
set y^e internal from B to
 a : Then take y^e nearest
distance from F ,
to y^e said HD & set y^e
internal from B to b :
lastly take y^e nearest
distance from G to y^e
Arch HD & set y^e distance
from B to c , &
then draw the concentric
three circles a, b, c ,
but these should be

8 divisions between y^e outer one & y^e inner one HD , y^e so y^e space
between them may be divided into 6 equal parts & then each one contains 10:

plot on paper by help of the Needle, and the degrees of angles, and length of lines taken in the field. On the upper side of this Instrument is turned a round hole, three inches, and a halfe Diameter, and about half an inch deep, in which is placed a Card divided commonly into 120 equall parts or degrees, and each of those into three, which makes 360 answerable to the degrees of the Theodolite, in which Card is also a Dial drawn to finde the hour of the day, and Azimuth of the Sun; within the Box, is hanged a Needle touched with a Load-stone, and covered over with a cleer glasse to preserve it from the weather.

On the upper part of this Instrument is also described a Table of naturall Sines, collected answerable to the Card in the box, that is to say, if the Card be divided but into 120 parts, the Sines must be so also; but if into 360, the Sines must be the absolute degrees of the Quadrant.

To this Instrument also belongeth two Sights, one double in length to the other, the longest containing about seven inches being placed and divided in all respects, as those hereafter mentioned in the description of the Plain Table. On the edge of the shorter Sight toward the upper part thereof, is placed a small Wye representing the Center of a supposed Circle, the Semidiameter whereof is the distance from the Wye to the edge of the Instrument underneath the same, which parts is imaginarily divided into sixty equall parts, and according to those divisions is the right line of divisions on the edge of the Instrument divided, and numbered by 5, 10, 15, from the perpendicular point to the end thereof. And also from the same point, on the upper edge of the Instrument is perfected the degrees of the Quadrant, supplying the residue of those which could not be expressed on the long Sight, from 28 to 90 by tens.

There is also belonging to these divisions a little Ruler, at one end whereof is a little hole to put it upon the wye, on the edge of the shorter Sight; and at the other end of this Ruler is placed a small Sight, directly over the fiducial edge thereof, which edge is likewise divided according to those divisions on the edge of the Instrument. To this short Sight is added a plummet to set the Instrument horizonsall. And this short Ruler, with the divisions thereof, and those on the edge of the Instrument serve for taking of altitudes chiefly, and for the reducing of hypotenusal to horizontal lines.

CHAP. IV.

A Description of the Plain Table, how it hath been formerly made, and how it is now altered, it being the most absolute Instrument of any other for a Surveyor to use, in that it performeth whatsoever may be done either by the Theodolite, Circumferentor, or any other Instrument, with the same ease and exactnesse.



The Table it selfe is a Parallelogram, containing in length about fourteen inches and a halfe, and in bredth eleven inches: it is composed of three severall boards, which may be taken asunder for ease and convenience in carriage. For the binding of these three boards fast when the Table is set together, there belongeth a joynted frame, so contrived, that it may be taken off, and put on the Table at pleasure: this frame also is to fasten a sheet of paper upon the Table, when you are to describe the plot of any field, or other inclosure by the Table. This frame must have upon it, neer the inward edge, Scales of equall parts on both sides, for the speedy drawing of parallel lines upon the paper; and also for the shifting of your paper, when one sheet will not hold your whole work.

Unto this Table belongeth a Ruler or Index, containing in length about sixteen inches or more, it being full as long as from angle to angle of your Table, it ought to be about two inches in bredth, and one third part of an inch in thicknesse. Upon this Ruler or Index two Sights must be placed; one whereof is double in length to the other, the longer containing in length about twelve inches, the other six: on the top of this shorter Sight is placed a brasse pin, and also a thred and plummet to place your Instrument horizontall. Through the longer Sight must be made a slit, almost the whole length thereof, These two sights thus prepared, are to be perpendicularly erected upon the Index; in such sort, that the Wyer on the top of the shorter Sight, and the slit on the longer Sight stand precisely over the fiduciall edge of the Index. The space or distance of these two Sights one from the other, is to be equall to the divided part of the longer Sight. Upon the longer Sight is to be placed a Vane of brasse, to be moved up and down at pleasure, through which a small hole is to be made, answerable to the slit in the same Sight. and the edge of the Vane.

By these Sights thus placed on the Index there is projected the Geometricall Square, whose side is the divided part of the long Sight

Sight (or the distance between the two Sights.) In the middle of the long Sight (through the whole breadth thereof) there is drawn a line called the line of Level, dividing the side of the projected Square into two equall parts: also the same side is on this Sight divided into a hundred equall parts, which are numbered upwards and downwards, from the line of Levell, by fives and tens to fifty, on either side, which divisions are called the Scale.

There is also on the same Sight another sort of division, representing the hypotenusal Lines of the same Square, as they increase by Unites, and are likewise numbered upwards and downwards from the line of Levell, from one to twelve, by 1, 2, 3, &c. sometimes signifying 101, 102, 103, &c. these divisions shew how much any hypotenusal or slope line drawn over the same Square, exceedeth the direct horizontall line, being the side of the same Square.

On this Sight there is a third sort of divisions, representing the degrees of a Quadrant (or as many as the same sight is capable to receive, which are about 25) numbered from the line of Levell upward and downward by fives and tens to 25, which divisions are called the Quadrant.

Unto this Instrument, as unto all others belong these necessary parts, as the Socket, the Staffe, the Box, and Needle, &c.

☞ According to this description, have Plain Tables formerly been made, but if unto it be added these additional parts and alterations (which make it lesse cumbersome then before) it will be the most exact, absolute and universall Instrument for a Surveyour that was ever yet invented.

First, Let the frame be so fitted to the Table, that it may go on easily either side being upwards, so that as one side is divided into equall parts, (as in the description) the other side may have projected upon it the 180 degrees of a Semicircle, from a Center noted in the superficies of the Table, which degrees must be numbered from the left hand towards the right (when the Center is next to you) by fives and tens to 180, and then beginning again, set 190, and so successively to 360. These degrees thus inserted are of excellent use in wet or stormy weather, when you cannot keep a sheet of paper upon your Table, either in respect of rain or winde. Also these degrees will make the Plain Table to be an absolute Theodolite, so that you may work with these degrees as if they were the degrees of a Theodolite.

Secondly, Upon the Index or Ruler before spoken of, (instead of the Sights before described) let there be placed two Sights, both of one length, and back-sighted, one having a slit below, and a threed above, and the other, a slit above, and a threed below, serving to look backward and forward at pleasure without turning about the Instrument, when the Needle is at quiet. The expedition that these back-sights will make, will best appear by practise, for using these

you shall need (in going about a field) to plant your Instrument but at every second angle.

Thirdly, for the ready taking of heights, and the reducing of Hypothenusall to Horizontall lines (instead of the divisions on the Sights before mentioned) let there be projected a Tangent line along the side of the Ruler, whose divisions must touch the very edge thereof, so that a Label or Ruler of Box or Brasse, which is hanged on a pin sticking in the side of one of the Back-sights, and having another small Sight at the end thereof, may move justly along the side of the Index; then (the Instrument standing horizontally if you look through this small Sight, and by the Pin on which the Label hangeth, moving the Label too and fro, till you espie the mark you look at, then will the Label shew you what Degree of the Tangent line is cut thereby. This one line thus projected upon the side of the Ruler performeth all the uses of those divided Sights, and is far better, and lesse cumbersome then them or a Quadrant, (such as I formerly described in *Planometria*) because the degrees are larger. This line of Tangents is projected on the Index from the foot of the farthestmost Sight, all along the Ruler to the foot of the nethermost Sight, and up the side thereof and is numbered from 1 to 90, by 10, 20, 30, 40, 50, &c. ending at the foot of the furthermost Sight, from whence the line proceeded.

The use of this line of Tangents in taking of Heights is shewed in the fourth Book, & is used with the Tables of Sines and Logarithms treated of in the third Book, without which Tables, (or something equivalent thereunto) this line of Tangents will be of little use, therefore it will be convenient to have upon the Index of your Table the lines of Artificiall Numbers, Sines, and Tangents, by which you may work any proportion required very speedily and exactly, so that if you be destitute of your Tables, these Lines will sufficiently help you.

There is yet another way by which you may take any altitude, or reduce Hypothenusall to Horizontall lines, only by Vulgar Arithmetick, without the help of Tables, by having a line of equall parts divided on the edge of the Index, and another line of the same equall parts on the Label, by which lines, and Vulgar Arithmetick, an Altitude may very well be taken.

Now because I intend only to shew in generall the use of these equall parts, I will therefore do it in this place, because I shall have occasion to speak no more thereof hereafter: The use thereof (briefely) is thus.

Suppose that the line A B were some Hill or Tower, whose Altitude you require; standing at C, and looking through the Sights in your Label till you espie the top of the Tower at A, there finding the Label to cut 230 of the equall parts, then measuring the distance from your station at C, to the foot of the Tower at B, you finde it to contain 650 foot, then to finde the altitude A B, say,

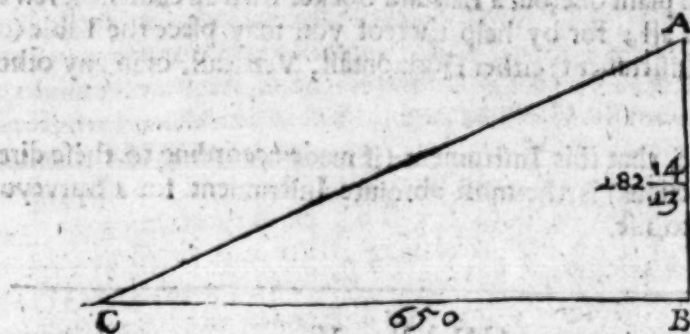
As

As 130, the parts cut by the Labell,

Is to 100;

So is 650, the measured distance C B,

To 282 $\frac{14}{23}$, the Altitude A B.



Therefore, multiply 650 by 100, and divide that Product by 230, the Quotient will be 282 $\frac{14}{23}$, for the altitude A B.

Now for the reducing of Hypothenufall to Horizontall lines, having measured the Hypothenufall line with your Chain, the proportion will be :

As the equall parts cut on the Label,

Are to the equall parts cut on the Index;

So is the length of the Hypothenufall line measured,

To the length of the Horizontall line required.

I thought good to give the Reader a view of the severall wayes there are to perform these conclusions, leaving every man at liberty to use that which he best liketh, or all if he please, for all the lines may very well be put upon one Instrument without any confusion of lines: but the way which I shall chiefly insist upon in the prosecuting of this Work, shall be by the line of Tangents, as being (in my opinion) the best of all. Now when I come to shew you the use of this line of Tangents, with the Tables of Sines and Logarithms in the resolving of Triangles, I will also shew you how to perform the same Propositions by the lines of Artificiall Numbers, Sines, and Tangents, and therefore I would advise every man to have these so necessary lines upon his Index.

Fourthly, Unto this Instrument also belongeth a Box and Needle, which is to be fastned to the side of the Table by help of two screws, so that it may be taken off and put on at pleasure. In the bottom of this Box must be placed a Card divided into 360 degrees numbered (if you please) after the usuall manner, from the North Eastward, but the Card by which all the Examples in this Book were

were framed was numbered from the North Westward by 10, 20, 30, &c. to 360, contrary to the common custome.

There belongeth also to this Instrument a Socket of Brasse to be screwed on the back side of the Table, into which must be put the head of the three legg'd Staffe; this Staffe ought to be joynted in the middle, so that it may be the more portable. For the Socket, it may be a plain one, but a Ball and Socket with an endlesse screw is the best of all, for by help thereof you may place the Table (or any other Instrument) either Horizontall, Verticall, or in any other position.

☞ Note, that this Instrument (if made according to these directions) is the most absolute Instrument for a Surveyor to use.

CHAP. V.

Of Chains, the severall sorts thereof.



F Chains there are divers sorts, as namely, Foot Chains, each link containing a Foot or 12 Inches, and so the whole Pole or Perch will contain 16½ Links or Feet, answering to the Statute denomination.

Some Chains have each Pole divided into 10 equall parts, and these are called Decimall Chains, and this grosse division may be convenient in some practises.

The Chains now used, and most esteemed amongst Surveyors, are especially two, namely, that generally used by Master *Rathborne*, which hath every Perch divided into 100 Links: and that of Master *Gunter*, which hath four Poles divided into 100 Links: so that each Link of Master *Gunters* Chain, is as long as four of Master *Rathborns*.

Now because these Chains are most esteemed of and used by Surveyors, I will therefore make a generall description of them both, leaving every man at liberty to take his choise.

Of Mr. RATHBORNS Chain.

THE Chain which Master *Rathborne* ordinarily used (as himselfe saith) contained in length two Statute Poles or Perches, each Pole containing in length 16½ feet, which is 198 Inches, then each Pole was divided into 10 equall parts called *Primes*, every of which contained in length 19½ Inches; again, every of those *Primes* was sub-divided into 10 other equall parts called *Seconds*, so that every of these *Seconds* contained in length 19½ Inch, so that the whole Pole, Perch, Unite, or Commencement (as he calleth it) was divided into 130 equall parts or Links, called *Seconds*.

The Chain (or one Pole thereof) being thus divided, at the end of every 50 Links or halfe Pole, let a large Curtain ring be fastned,

so shall you have in a whole Chain of two Perches long, three of these Rings, the middlemost being the division of the two Poles. Then at the end of every *Prime*, that is, at the end of every ten Links, let a smaller Curtain Ring be fastened.

By this distinction of Rings, the Chain is divided into these three denominations, *Unites*, *Primes*, and *Seconds*, whose Characters are these, . . . , so that if you would expresse 40 *Unites*, 8 *Primes*, and 7 *Seconds*, they are thus to be written, 4087, by which you may perceive that those Figures which have no pricks over them are *Unites* or *Integers*, and the figure under the first point *Primes*, and under the next *Seconds*: so also, three *Unites*, seven *Primes*, and two *Seconds*, will stand thus, 372.

Besides these divisions, Master *Rathborn* for his own use, sewed at the end of every two *Primes* and a halfe (which is a quarter of a Pole) a small red cloth, and at every seven *Primes* and a halfe (being three quarters of a Pole) the like of yellow, or other discernable colour, which much helped him in the ready reckoning of the several Rings upon the Chain, remembering this Rule: That if it be the next Ring short of the Red, it is two *Primes*, if the next over three, if the next short of the yellow, seven *Primes*, if the next over eight, if the next short of the great halfe Ring it is four, the next over six: and if the next short of the middle great Ring, it is nine, and if the next over one.

☞ But here is to be noted, that if you use this distinction by colours, you must alwayes work with one end of the Chain from you.

This Chain being thus divided and marked, you have every whole Pole equall to ten *Primes*, or 100 *Seconds*: every three quarters of a Pole, equall to seven *Primes* and a halfe, or 75 *Seconds*: every halfe Pole equall to five *Primes*, or 50 *Seconds*: and lastly, every quarter of a Pole equall to two *Primes* and a halfe, or 25 *Seconds*.

And here is to be noted, that in the ordinary use of this Chain, for measuring and platting, you need take notice only of *Unites* and *Primes*, which is exact enough for ordinary use, but in case that separation or division of Lands into severall parts, you may make use of *Seconds*.

OF M^r. GUNTERS Chain.

AS every Pole of Master *Rathborns* Chain was divided into 100 Links, so Master *Gunters* whole Chain (which is alwayes made to contain four Poles) is divided into 100 Links, one of these Links being four times the length of the other. Now if this Chain be made according to the Statute, each Perch to contain 16½ Feet, then each Link of this Chain will contain 7 Inches, and ½ of an Inch, and the whole Chain 729 Inches, or 66 Foot.

In measuring with this Chain, you are to take notice only of Chains

Chains and Links, as saying such a line measured by the Chain contains 72 Chains 48 Links, which you may expresse more briefly thus, 72,48, and these are all the Denominations which are necessary to be taken notice of in Surveying of Land.

For the ready counting of the Links of this Chain, there ought to be these distinctions, namely, In the middle thereof, which is at two Poles end, let there be hanged a large Ring, or rather a plate of brasse like a Rhombus, so is the whole Chain (by this plate) divided into two equall parts.

Secondly, Let each of these two parts be divided into two other equall parts, by smaller Rings or Circular plates of brasse, so shall the whole Chain be divided into four equall parts or Perches, each Perch containing 25 Links.

Thirdly, At every ten Links let be fastened a lesser Ring then the former, or else a Plate of some other fashion, as a Semicircle, or the like. And lastly, at every fift link (if you please) may be fastened other marks, so by this means you shall most easily and exactly count the Links of your Chain without any trouble. The Chain being thus distinguished, it mattereth not which end thereof be carryed forward, because the notes of distinction proceed alike on both sides from the middle of the Chain.

¶ Here note, that in all the examples in this Book, the lines are supposed to be measured by this four Pole Chain of Master Gunter, it being the best of any other: the manner how to cast up the content of any plot measured therewith shall be hereafter taught in its due place.

Cautions to be observed in the use of any Chain.

IN measuring a large distance with your Chain, you may casually mistake or misse a Chain or two in keeping your account, from whence will ensue a considerable error: Also in measuring of distances (when you go not along by a hedge side) you can hardly keepe your Instrument, Chain, and Mark, in a right line, which if you do not, you must necessarily make your measured distance greater then in reality it is. For the avoyding of either of these mistakes, you ought to provide ten small sticks or Arrows, which let him that leadeth the Chain carry in his hand before, and at the end of every Chain, stick one of these Arrows into the ground, which let him that followeth the Chain take up, so going on till the whole number of Arrows be spent, and then you may conclude that you have measured ten Chains, without any further trouble, and these ten Chains (if the distance you are to measure be large) you may call a Change, and so you may denominate every large distance by Changes, Chains, and Links. Or you may at the end of every ten Chains set up another kinde of stick, by which (standing at the Instrument) you may see whether your eye, the stick, and the Mark to which you are to measure be in a right line or not, and accordingly guide those that

that carry the Chain, with the more exactness to direct it to the Mark intended.

How to reduce any number of Chains and Links, into Feet.

IN the practise of many Geometrical Conclusions, as in the taking of Heights and Distances, hereafter taught, it is requisite to give your measure (in such cases) in Feet or Yards, and not in Poles or Perches; yet because your Chain is the most necessary Instrument to measure withall, I thought it convenient in this place to shew you how to reduce any number of Chains and Links into Feet, which is thus.

Multiply your number of Chains and Links together as one whole number, by 66, cutting off from the product the two last figures towards the right hand, so shall the rest of the product be Feet, and the two figures cut off shall be hundred parts of a Foot.

EXAMPLE.

Let it be required to know how many Feet are contained in 5 Chains, 32 Links. First, Set down your 5 Chains, 32 Links as is before taught, and as you see in the first Example, with a Comma between the Chains and Links, then multiplying this 5 Chains, 32 Links by 66, the product will be 35112, from which, cut off the two last figures toward the right hand with a Comma, then will the number be 351,12, which is 351 Feet and 12 parts of a foot, and so many Feet are contained in 5 Chains, 32 Links.

Example I.

$$\begin{array}{r} 5,32 \\ \times 66 \\ \hline 3192 \\ 3192 \\ \hline 351,12 \end{array}$$

Example II.

$$\begin{array}{r} 9,05 \\ \times 66 \\ \hline 5430 \\ 5430 \\ \hline 597,30 \end{array}$$

But let the number of Chains be what they will, if the number of Links be less than 10, as in the second Example it is 9 Chains 5 Links, you must place a Cypher before the five Links as there you see, and then multiplying that number (viz. 9,05) by 66, the product will be 59730, from which taking the two last figures, there will remain 597 Feet, and 30 parts of a Foot. The like may be done for any other number of Chains and Links whatsoever.

According to these Examples is made the Table following, which sheweth how many Feet are contained in any number of Chains and Links, from 5 Links to 10 Chains, for every fifth Link, which is sufficient for ordinary use; by which Table you may see that


in 6 Chains 40 Links, is contained 480 Feet, and $\frac{1}{10}$ of a Foot,
Also in 5 Chains 55 Links is contained 366 Feet, and $\frac{1}{10}$ parts of
a Foot: and so of any other.

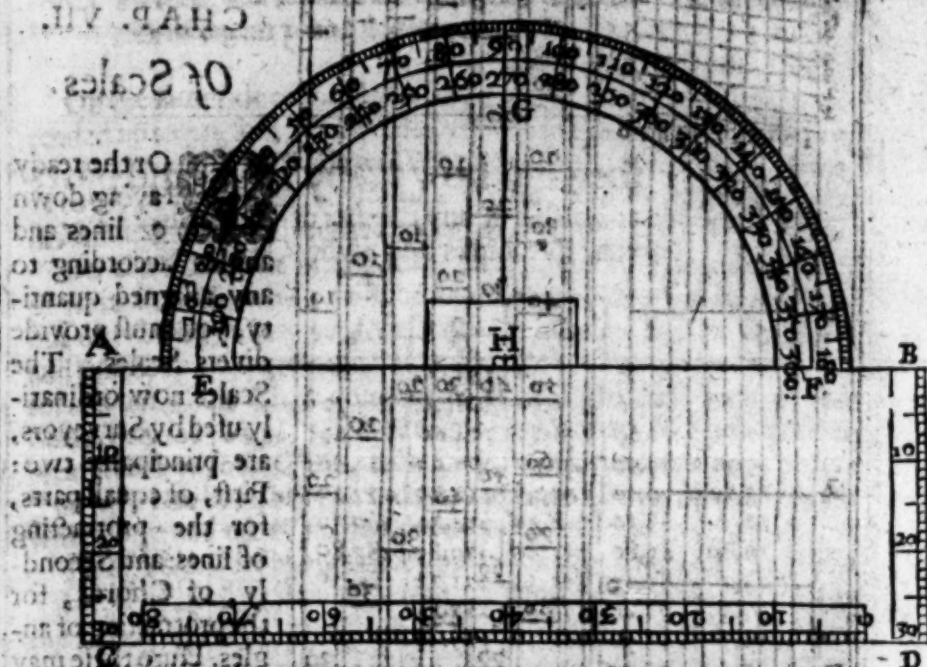
A TABLE shewing how many Feet, and parts
of a Foot are contained in any number of Chains and Links
between five Links and eight Chains.

	0	1	2	3	4	5	6	7
0	0	66,00	132,00	198,00	264,00	330,00	396,00	462,00
5	3,30	69,30	135,60	201,90	268,20	334,50	400,80	467,10
10	6,60	72,60	138,60	204,60	270,60	336,60	402,60	468,60
15	9,90	75,90	141,90	207,90	273,90	339,90	405,90	471,90
20	13,20	79,20	145,20	211,20	277,20	343,20	409,20	475,20
25	16,50	82,50	148,50	214,50	280,50	346,50	412,50	478,50
30	19,80	85,80	151,80	217,80	283,80	349,80	415,80	481,80
35	23,10	89,10	155,10	221,10	287,10	353,10	419,10	485,10
40	26,40	92,40	158,40	224,40	290,40	356,40	422,40	488,40
45	29,70	95,70	161,70	227,70	293,70	359,70	425,70	491,70
50	33,00	99,00	165,00	231,00	297,00	363,00	429,00	495,00
55	36,30	102,30	168,30	234,30	300,30	366,30	432,30	498,30
60	39,60	105,60	171,60	237,60	303,60	369,60	435,60	501,60
65	42,90	108,90	174,90	240,90	306,90	372,90	438,90	504,90
70	46,20	112,20	178,20	244,20	310,20	376,20	442,20	508,20
75	49,50	115,50	181,50	247,50	313,50	379,50	445,50	511,50
80	52,80	118,80	184,80	250,80	316,80	382,80	448,80	514,80
85	56,10	122,10	188,10	254,10	320,10	386,10	452,10	518,10
90	59,40	125,40	191,40	257,40	323,40	389,40	455,40	521,40
95	62,70	128,70	194,70	260,70	326,70	392,70	458,70	524,70

CHAP. VI.

Of the Protractor.

 Protractor is an Instrument by which you may Protract
or lay down upon paper or otherwise, the true symetry or
proportion of any field, having made observation of the
sides and angles thereof by some of the Instruments be-
fore described. This Instrument consisteth of two parts, the one
is a Semicircle divided into degrees, as in the figure of the Table,
and the other is a Scale divided into equal parts, the Semicircle be-
ing to lay down the angles, and the Scale to plot the sides. This
Instrument ought to be made of a piece of thin brass well polished,
the edges thereof being very smooth, and the Scale thereof, namely,
the right angled Parallelogram, or long square containing in length
from A to B about 4 inches and three quarters, and in breadth from
A to C about one and a half. Let the two ends of the Scale,
namely,



namely, the sides *A C* and *B D* be divided into equal parts of 16 or 20 in an Inch, and let the side *C D* be divided according to a Scale of 10 or 12 in an Inch.

The Scale being thus divided, on the middle of the line *A B*, as at *H*, describe the Semicircle *E G F*, which divide into two Quadrants in the point *G*, by help of the perpendicular *H G*: then divide each of those Quadrants into 90 equal parts called degrees, so shall the whole Semicircle contain 180 degrees, which must be numbered by 10, 20, 30, 40, &c. to 180, from *E* by *G* to *F*, and the same way also from 180 to 360, as you see done in the Figure, the numbers of the first Semicircle from 00 to 180 being for the East side of the Protractor, and the other numbers from 180 to 360 for the West side.

Now you are to note, that the line *A B* alwayes representeth the Meridian line, and is sometimes noted with the letters *S* and *N*, for South and North, but then it is necessary that the Protractor be divided on either side the plate, which this double numbering avoydeth: for the line *A B* being taken for the Meridian in general, the Semicircle of the Protractor may be turned any way (either upward or downward) and so one Semicircle being divided will be sufficient, yet if any man be desirous, he may have it made according to his own fancy, but this manner of numbering (in my opinion) is the best, it being most agreeable to your Instruments.

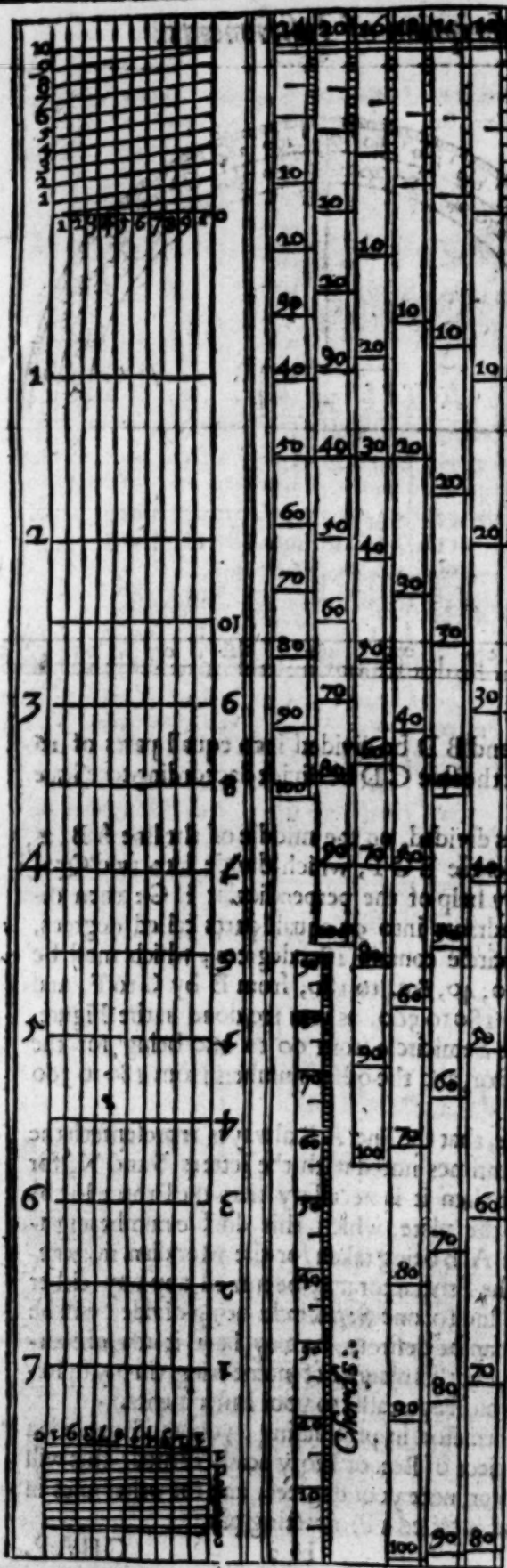
To use with this Protractor in protracting, you must provide a fine needle, put into a piece of Box or Ivory neatly turned, this will serve to fix in your center, note your degrees, and for other uses in drawing your Plot, and is called a Protracting pin.

CHAP. VII.

Of Scales.

OR the ready laying down of lines and angles according to any assigned quantity, you must provide divers Scales. The Scales now ordinarily used by Surveyors, are principally two: First, of equal parts, for the protracting of lines: and Secondly, of Chords, for the protracting of angles. Unto these may be added, Thirdly, a Diagonal Scale, which is (indeed) no other then a Scale of equal parts more scrupulously divided. If you desire a convenient Scale, let it be made in this manner, to contain in length about 8 or 9 Inches, & in breadth one Inch and a quarter: on one side thereof let be placed divers Scales, as of 10, 11, 12, 16, 20, 24, and 30 in an Inch.

Here is to be noted, that when I say a Scale of 12 in an Inch, you are to understand a part of a line divided into 12 equal parts, 12 of which parts would make an



an Inch, and the like is to be understood of any other number of equall parts whatsoever.

On the same side of the Ruler let be placed a line of Chords extended up to 90, and numbered as you see in the figure, by 10, 20, 30, &c. to 90. This Scale will be of good use for many purposes, as to divide the circumference of a Circle, and to protract angles, in some cases better then the Protractor.

On the other side of the Ruler let be drawn a Diagonall Scale, of 10 in an Inch; which will be an excellent Scale for large Plots, out of which you may very well take the hundred part of an Inch, and this Scale will agree with your four Pole Chain exceeding well, for as your whole Chain contains 100 Links, so each Inch of this Scale contains 100 parts, so that out of it you may take any number measured by your Chain, to a Link, and lay it down upon paper. You may also have half an Inch divided into 100 parts, which Scale will be of good use also to lay down a small Plot.

These Scales are many times put upon the Index of the Plain Table, because they should be ready in hand when you survey by the Table, and plot your work as you go, but if you use the degrees on the Frame of the Table, or the Circumferentor, and keepe your account in a Book, then I would advise you to have your Scale of Brasse or Box neatly and exactly divided.

To use with this Scale, you must provide a pair of beare Compasses of Brasse, with steel points, filed very small, and also a new pair of Compasses with three points, and Screws to alter the points, so that you may draw lines or Circles with black lead, or any coloured Inke, which will be very necessary and convenient in beautifying of your Plots after Protraction.

CHAP. VIII.

Of a Field-Book.

IT will be sufficient in this place only to describe the manner how a Field-Book ought to be ruled: Let the Book contain any quantity of paper, more or lesse, and in what volume you please. Let it be ruled, towards the left Margine of every page, with five lines in red inke, so shall you have four Columns, in the first whereof you must note down the degrees cut either by the Index on the frame of the Table, or else by the Needle on the Card, at every angle you observe, and the second Column is to note the minutes or parts of a Degree, for you are to note, that every degree on the frame of the Table, or in the Card of the Circumferentor, is supposed to be divided into 60 other parts called Minutes, which cannot be expressed by reason of the smallness of the Instruments, and therefore must only be estimated, yet if your Instrument be large enough, you may have each degree divided

The manner how a Field-Book ought to be ruled.

Degrees.	Minutes.	Chains.	Links.
326	45	16	87

divided into 3 equal parts, so shall every part contain 40 minutes. The other two Columns serve to note down the lengths measured by your Chain, as the Chains & Links.

Now suppose

that making any observation in the Field either with the Degrees on the frame of the Table, or with the Circumferentor, and then observing any angle, (as is hereafter taught) you find the Index, of the Plain Table, or the Needle in the Circumferentor, to cut 326 degrees, 45 minutes, these 326 degrees must be set down in the first Column of your Field-Book, and the 45 minutes in the second Column, as you see here done. Also if you measure any length in the Field with your Chain, as suppose some distance measured to contain 16 Chains, 87 Links, the 16 Chains must be set in the third Column, and the 87 Links in the fourth Column, under their respective Titles, as you see here done.

CHAP. IX.

Of Instruments for Reducing of Plots.

TOr the reducing of Plots from one forme to another, there hath been divers Instruments invented by divers men. One that performeth that work very well, is a Ruler, having fixed at each end thereof a Semicircle divided into degrees, and another Ruler having two Semicircles to move thereon, upon the centers of all these Semicircles there are thin rulers of Brasse to move from angle to angle of your Plot: but the manner of working by these Semicircles being very tedious, I passe it over. Another way is by having certain proportionall Scales upon one and the same Ruler as Master *Lathe* describeth, but this I shall also wave, and likewise that which I described in *Planometria*, as being too particular. The best and most absolute is a Parallelogram, the making whereof is well known to the Instrument-maker.

The end of the Second Book.

THE COMPLETE SURVEYOR.

The Third Book.

THE ARGUMENT.

His Third Book is as it were a Key to those that follow, the subject where of is Trigonometry. Now forasmuch as the whole Art of measuring heights and distances, and plotting and protracting of Land, and all other lineall and superficiall dimensions are grounded upon the resolution of Plain Triangles, I hold it convenient (before I come to the practise of Surveying, or to shew the use of any Instrument in taking of heights and distances) to say something concerning Plain Triangles

Triangles (at least so much as is necessary for a *Surveyor* to know) though that *subject* be already handled by divers able *Mathematicians* already, whose *Works* are extant: viz. *Pitiscus*, *Snelius*, the Lord *Nepair*, Master *Gunter*, Master *Norwood*, Master *Gellibrand*, &c. Now because the readiest way of resolving *Triangles* is by *Sines*, *Tangents*, and *Logarithmes*, I have therefore added brief *Tables* for that purpose, viz. a *Table* of *Sines* to every tenth minute of the *Quadrant*, and a *Table* of *Logarithmes* from 1, to 1000, which will be large enough for ordinary use in *Surveying*, but, those who desire to make a further scrutiny into *Trigonometry*, may peruse the fore-mentioned *Authors*. In this *Book* I have only insisted upon such *Cases*, as may come in use in *Surveying*, and therefore have omitted divers, yet those which I have insisted on, are performed both by the *Tables* following in this *Book*, and also by the *Lines* of *Artificiall Numbers*, *Sines* and *Tangents* before spoken of in the description of the *Index* of the *Plain Table* in the last *Book*.

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 I have added a *Table* of *Sines*, and a *Table* of *Logarithmes*,
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Book, and also by the *Lines* of *Artificiall Numbers*, *Sines*
 and *Tangents* before spoken of in the description of the
Index of the *Plain Table* in the last *Book*.



TRIGONOMETRIE.

CHAP. I.

The Elpation and Use of the Table of SINES.



Before I come to the mensuration of Triangles, it will be necessary to explain and shew the use of the Tables of *Sines* and *Logarithms* following, by which Tables the sides or angles of right lined Triangles may be readily and exactly measured, so that in any plain Triangle, if there be any three parts thereof given, a fourth may be easily discovered.

The Table of *Sines* consisteth of two Rows or Columns, the first whereof sheweth the Degrees and Minutes of the Quadrant, having over the head thereof these two letters, *D. M.* standing for Degrees and Minutes. In the second Column is the Artificial *Sines* answering to every Degree, and 10th Minute of the Quadrant, having the word *Sine* over the head thereof. The use of this Table will appear by the following Propositions.

PRO P. I.

Any Degree and Minute being given, to finde the Sine thereof.

First, Seeke the Degree and minute in the first Column of the Table, under *D. M.* and right against it, in the next Column towards the right hand, under the word *Sine*, you shall have your desire.

EXAMPLE. I.

Suppose it were required to finde the Sine of 20 degrees, First, you must seeke 20 in the first Column of the Table under *D. M.* and right against 20 in the second Column under the word *Sine*, you shall finde 9,534052, which is the Sine of 20 Degrees.

In the same manner you shall finde the Sine of 50 degrees to be 9,884254, and the Sine of 76 degrees to be 9,986904.

EXAMPLE. II.

Let it be required to finde the Sine of 40 degrees, 30 minutes. First, you must finde 40 30 (which is 40 degrees 30 minutes) in the first Column, under the letters *D. M.* and against it you shall finde 9,812544, which is the Sine of 40 degrees, 30 minutes.

Also the Sine of 62 degrees 10 minutes. will be found to be 9,946604, and the Sine of 86 degrees 30 minutes will be 9,999189, and in this manner may you finde the artificiall Sine of any number of Degrees and minutes expressed in the Table.

PROP. II.

Any Sine being given, to finde the number of degrees and minutes thereunto belonging.

EXAMPLE.

Let 9,866470 be a Sine given, and let it be required to finde the degrees and minute of the Quadrant answering thereunto. First, seeke in the second Column amongst the Sines for 9,866470, and against it (on the left hand) you shall finde 47 degrees 30 minutes, which is the arch of the Quadrant answering thereunto.

Again, Let it be required to finde the arch answering to this Sine 9,821364, having found 9,821364 in the second Column under the word *Sine*, against it you shall finde 41 degrees 30 min. and that is the arch or degree answering thereunto.

But in case you have a number given which you cannot exactly finde in the Table, you must then instead thereof, take the neerest in the Table. As if your number given were 9,675859, if you looke in the Table for this number it cannot be found there, but the neerest thereunto is 9,676328, which is the Sine of 28 degrees 20 minutes, which you must take instead thereof.

THE

Table, under *D. M.* and right against it, in the first Column of the Table, you shall finde the number of degrees and minutes thereunto belonging.

The Table of Sines.

D. M.	Sines	D. M.	Sines	D. M.	Sines
0	0,000000	8	0,143555	16	0,2740338
10	7,463726	10	0,152451	18	0,3090172
20	7,764754	20	0,161164	20	0,3449054
30	7,940842	30	0,169702	30	0,3813342
40	8,065776	40	0,178072	40	0,4181784
50	8,162681	50	0,186280	50	0,4553935
1	8,241855	9	0,194332	17	0,3240446
10	8,308794	10	0,202234	18	0,3614115
20	8,366777	20	0,209992	20	0,399142
30	8,417919	30	0,217609	30	0,4372128
40	8,463665	40	0,225092	40	0,4756075
50	8,505045	50	0,232444	50	0,5143982
2	8,542819	10	0,239670	18	0,5536075
10	8,577566	10	0,246795	19	0,5933851
20	8,609734	20	0,253761	20	0,633682
30	8,639679	30	0,260633	30	0,674476
40	8,667689	40	0,267395	40	0,7157234
50	8,693998	50	0,274049	50	0,7574955
3	8,718800	11	0,280599	19	0,7998642
10	8,742359	10	0,287048	20	0,8428394
20	8,764511	20	0,293399	20	0,8863911
30	8,785675	30	0,299655	30	0,9305495
40	8,805852	40	0,305819	40	0,97527046
50	8,825130	50	0,311899	50	0,9530565
4	8,843584	12	0,317879	20	0,9534052
10	8,861283	10	0,323780	10	0,9537507
20	8,878285	20	0,329599	20	0,9540931
30	8,894643	30	0,335337	30	0,9544325
40	8,910404	40	0,340996	40	0,9547689
50	8,925609	50	0,346579	50	0,9551024
5	8,940296	13	0,352088	21	0,9554329
10	8,954499	10	0,357524	10	0,9557606
20	8,968249	20	0,362889	20	0,9560855
30	8,981573	30	0,368185	30	0,9564075
40	8,994497	40	0,373414	40	0,9567269
50	9,007044	50	0,378577	50	0,9570435
6	9,019235	14	0,383675	22	0,9573575
10	9,031089	10	0,388711	10	0,9576689
20	9,042625	20	0,393685	20	0,9579777
30	9,053859	30	0,398600	30	0,9582840
40	9,064806	40	0,403455	40	0,9585877
50	9,075480	50	0,408254	50	0,9588890
7	9,085894	15	0,412996	23	0,9591878
10	9,096062	10	0,417684	10	0,9594842
20	9,105992	20	0,422317	20	0,9597783
30	9,115698	30	0,426899	30	0,9600700
40	9,125187	40	0,431429	40	0,9603594
50	9,134470	50	0,435918	50	0,9606465

The Table of Sines.

D. M.	Sines	D. M.	Sines	D. M.	Sines
24 0	9,609313	32 0	9,724210	40 0	9,808067
10	9,612148	10	9,726225	10	9,809569
20	9,614944	20	9,728227	20	9,810061
30	9,617727	30	9,730216	30	9,812544
40	9,620488	40	9,732193	40	9,814019
50	9,623229	50	9,734157	50	9,815485
25 0	9,625948	33 0	9,736109	41 0	9,816943
10	9,628647	10	9,738048	10	9,818392
20	9,631326	20	9,739975	20	9,819832
30	9,633984	30	9,741889	30	9,821264
40	9,636623	40	9,743792	40	9,822688
50	9,639242	50	9,745683	50	9,824104
26 0	9,641842	34 0	9,747562	42 0	9,825511
10	9,644423	10	9,749429	10	9,826910
20	9,646984	20	9,751284	20	9,828301
30	9,649527	30	9,753128	30	9,829683
40	9,652052	40	9,754960	40	9,831058
50	9,654558	50	9,756781	50	9,832425
27 0	9,657047	35 0	9,758591	43 0	9,833783
10	9,659517	10	9,760390	10	9,835134
20	9,661970	20	9,762177	20	9,836477
30	9,664406	30	9,763954	30	9,837812
40	9,666824	40	9,765720	40	9,839140
50	9,669225	50	9,767474	50	9,840459
28 0	9,671609	36 0	9,769219	44 0	9,841771
10	9,673977	10	9,770952	10	9,843079
20	9,676328	20	9,772675	20	9,844372
30	9,678663	30	9,774388	30	9,845662
40	9,680982	40	9,776090	40	9,846944
50	9,683284	50	9,777781	50	9,848218
29 0	9,685571	37 0	9,779463	45 0	9,849485
10	9,687842	10	9,781134	10	9,850745
20	9,690098	20	9,782796	20	9,851997
30	9,692339	30	9,784447	30	9,853242
40	9,694564	40	9,786088	40	9,854480
50	9,696774	50	9,787720	50	9,855710
30 0	9,698970	38 0	9,789342	46 0	9,856934
10	9,701151	10	9,790954	10	9,858150
20	9,703317	20	9,792557	20	9,859360
30	9,705469	30	9,794149	30	9,860562
40	9,707606	40	9,795733	40	9,861757
50	9,709730	50	9,797307	50	9,862946
31 0	9,711839	39 0	9,798872	47 0	9,864127
10	9,713935	10	9,800427	10	9,865302
20	9,716017	20	9,801973	20	9,866470
30	9,718085	30	9,803510	30	9,867631
40	9,720140	40	9,805038	40	9,868785
50	9,722181	50	9,806557	50	9,869933

The Table of Sines.

D. M.	Sines	D. M.	Sines	D. M.	Sines
48	0 9,871073	56	0 9,918574	64	0 9,953660
10	9,872208	10	9,919424	10	9,954274
20	9,873335	20	9,920268	20	9,954883
30	9,874456	30	9,921107	30	9,955488
40	9,875571	40	9,921940	40	9,956088
50	9,876678	50	9,922768	50	9,956684
0	9,877780	57	0 9,923591	65	0 9,957276
10	9,878875	10	9,924409	10	9,957862
20	9,879963	20	9,925222	20	9,958445
30	9,881045	30	9,926029	30	9,959023
40	9,882121	40	9,926831	40	9,959596
50	9,883191	50	9,927628	50	9,960165
0	9,884254	58	0 9,928420	66	0 9,960730
10	9,885311	10	9,929207	10	9,961290
20	9,886361	20	9,929989	20	9,961846
30	9,887406	30	9,930766	30	9,962398
40	9,888444	40	9,931537	40	9,962945
50	9,889476	50	9,932304	50	9,963488
0	9,890503	0	9,933066	67	0 9,964026
10	9,891522	59	10 9,933822	10	9,964560
20	9,892536	20	9,934574	20	9,965090
30	9,893544	30	9,935320	30	9,965615
40	9,894546	40	9,936062	40	9,966136
50	9,895542	50	9,936799	50	9,966653
0	9,896532	60	0 9,937531	68	0 9,967166
10	9,897516	10	9,938257	10	9,967674
20	9,898494	20	9,938980	20	9,968178
30	9,899467	30	9,939697	30	9,968678
40	9,900433	40	9,940409	40	9,969173
50	9,901391	50	9,941116	50	9,969665
0	9,902349	61	0 9,941819	69	0 9,970152
10	9,903298	10	9,942517	10	9,970634
20	9,904241	20	9,943210	20	9,971112
30	9,905179	30	9,943898	30	9,971588
40	9,906111	40	9,944582	40	9,972058
50	9,907037	50	9,945261	50	9,972524
0	9,907958	62	0 9,945935	70	0 9,972986
10	9,908873	10	9,946604	10	9,973443
20	9,909782	20	9,947269	20	9,973897
30	9,910686	30	9,947929	30	9,974346
40	9,911584	40	9,948584	40	9,974792
50	9,912477	50	9,949235	50	9,975233
0	9,913364	63	0 9,949881	71	0 9,975670
10	9,914246	10	9,950522	10	9,976103
20	9,915123	20	9,951159	20	9,976532
30	9,915994	30	9,951791	30	9,976956
40	9,916859	40	9,952419	40	9,977377
50	9,917719	50	9,953042	50	9,977794

The Table of Sines.

D. M.	Sines	D. M.	Sines	D. M.	Sines
72	0 9,978206 10 9,978615 20 9,979019 30 9,979419 40 9,979816 50 9,980208	78	0 9,990404 10 9,990671 20 9,990934 30 9,991193 40 9,991448 50 9,991699	84	0 9,997614 10 9,997734 20 9,997873 30 9,997996 40 9,998106 50 9,998232
73	0 9,980596 10 9,980980 20 9,981361 30 9,981737 40 9,982109 50 9,982477	79	0 9,991947 10 9,992190 20 9,992430 30 9,992666 40 9,992898 50 9,993127	85	0 9,998344 10 9,998453 20 9,998558 30 9,998659 40 9,998757 50 9,998851
74	0 9,982842 10 9,983202 20 9,983558 30 9,983910 40 9,984259 50 9,984603	80	0 9,993351 10 9,993572 20 9,993789 30 9,994003 40 9,994212 50 9,994418	86	0 9,998941 10 9,999127 20 9,999110 30 9,999189 40 9,999265 50 9,999336
75	0 9,984943 10 9,985280 20 9,985613 30 9,985942 40 9,986266 50 9,986587	81	0 9,994620 10 9,994818 20 9,995012 30 9,995203 40 9,995390 50 9,995573	87	0 9,999404 10 9,999469 20 9,999529 30 9,999586 40 9,999640 50 9,999689
76	0 9,986904 10 9,987217 20 9,987526 30 9,987832 40 9,988133 50 9,988430	82	0 9,995753 10 9,995928 20 9,996100 30 9,996269 40 9,996433 50 9,996594	88	0 9,999735 10 9,999778 20 9,999816 30 9,999851 40 9,999882 50 9,999910
77	0 9,988724 10 9,989014 20 9,989299 30 9,989581 40 9,989860 50 9,990134	83	0 9,996751 10 9,996904 20 9,997053 30 9,997199 40 9,997341 50 9,997480	89	0 9,999934 10 9,999954 20 9,999971 30 9,999983 40 9,999993 50 9,999998

CHAP. II.

*The Explanation and Use of the Table
of LOGARITHMS.*

The Table of Logarithms following consisteth of two Rows or Columns; the first of which (namely that towards the left hand, having the word *Num.* at the head thereof) containeth all absolute numbers increasing by a Unite in continuall proportion from 1, to 1000.

In the other Column is placed the Logarithms of those absolute numbers; which Logarithms are numbers so fitted to proportionall numbers, that themselves retain equal differences.

By this Table, the Logarithme of any absolute number under 1000, may be readily found: Or if any Logarithme, whose absolute number exceedeth not 1000, be given, this Table will plainly discover what absolute number answereth thereunto. The use of this Table will appear by the Propositions following.

PROP. I.

A number being given, to finde the Logarithme thereof.

Let it be required to finde the Logarithm of 223, First, seeke 223 in the first Column of the Table under the word *Num.* and against it in the second Column you shall finde 2,348305, which is the Logarithm thereof.

Also, Let it be required to finde the Logarithm of 629, if you seeke 629 in the first Column, against it in the second you shall finde 2,798691, which is the Logarithm thereof.

PROP. II.

A Logarithme being given, how to finde the absolute number thereunto belonging.

Let 2,731389 be a Logarithm given, whose absolute number you require: you must first seeke this number in the second Column of the Table, under the word *Log.* against which you shall finde 539, which is the absolute number answering to that Logarithme.

But in this Table, as in the Table of *Sines*, if you cannot finde the direct Logarithm which you looke for, in the Table, you must take the nearest thereunto.

THE

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
1	0,000000	51	1,707570	101	2,004121
2	0,301030	52	1,716003	102	2,008600
3	0,477121	53	1,724276	103	2,012877
4	0,602060	54	1,732394	104	2,017031
5	0,698970	55	1,740363	105	2,021169
6	0,778151	56	1,748188	106	2,025198
7	0,845098	57	1,755875	107	2,029184
8	0,903090	58	1,763428	108	2,033124
9	0,954242	59	1,770852	109	2,037026
10	1,000000	60	1,778151	110	2,040891
11	1,041393	61	1,785330	111	2,044718
12	1,079181	62	1,792392	112	2,048518
13	1,113943	63	1,799341	113	2,052298
14	1,146128	64	1,806180	114	2,056058
15	1,176091	65	1,812912	115	2,059798
16	1,204110	66	1,819544	116	2,063418
17	1,230449	67	1,826075	117	2,066918
18	1,255272	68	1,832509	118	2,070388
19	1,278754	69	1,838849	119	2,073757
20	1,301030	70	1,845098	120	2,077011
21	1,322219	71	1,851258	121	2,080275
22	1,342423	72	1,857332	122	2,083459
23	1,361728	73	1,863323	123	2,086565
24	1,380211	74	1,869232	124	2,089595
25	1,397940	75	1,875061	125	2,092649
26	1,414973	76	1,880814	126	2,095627
27	1,431364	77	1,886491	127	2,098530
28	1,447158	78	1,892095	128	2,101359
29	1,462398	79	1,897627	129	2,104113
30	1,477121	80	1,903089	130	2,106791
31	1,491362	81	1,908485	131	2,109394
32	1,505150	82	1,913814	132	2,111921
33	1,518514	83	1,919078	133	2,114372
34	1,531479	84	1,924279	134	2,116747
35	1,544068	85	1,929419	135	2,119046
36	1,556301	86	1,934498	136	2,121269
37	1,568202	87	1,939519	137	2,123416
38	1,579783	88	1,944483	138	2,125487
39	1,591065	89	1,949390	139	2,127482
40	1,602060	90	1,954242	140	2,129401
41	1,612784	91	1,959041	141	2,131244
42	1,623249	92	1,963788	142	2,133011
43	1,633468	93	1,968483	143	2,134701
44	1,643453	94	1,973128	144	2,136314
45	1,653212	95	1,977724	145	2,137851
46	1,662758	96	1,982271	146	2,139312
47	1,672098	97	1,986772	147	2,140697
48	1,681241	98	1,991226	148	2,142006
49	1,690196	99	1,995635	149	2,143239
50	1,698970	100	2,000000	150	2,144396

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
151	2,178977	201	2,303196	251	2,399674
152	2,181844	202	2,305351	252	2,401401
153	2,184691	203	2,307496	253	2,403121
154	2,187521	204	2,309630	254	2,404834
155	2,190332	205	2,311754	255	2,406540
156	2,193125	206	2,313867	256	2,408239
157	2,195899	207	2,315970	257	2,409933
158	2,198657	208	2,318063	258	2,411619
159	2,201397	209	2,320146	259	2,413299
160	2,204119	210	2,322219	260	2,414973
161	2,206826	211	2,324282	261	2,416641
162	2,209515	212	2,326336	262	2,418301
163	2,212187	213	2,328379	263	2,419956
164	2,214844	214	2,330414	264	2,421604
165	2,217484	215	2,332438	265	2,423246
166	2,220108	216	2,334454	266	2,424882
167	2,222716	217	2,336459	267	2,426511
168	2,225309	218	2,338456	268	2,428135
169	2,227887	219	2,340444	269	2,429752
170	2,230449	220	2,342427	270	2,431364
171	2,232996	221	2,344392	271	2,432969
172	2,235528	222	2,346353	272	2,434569
173	2,238046	223	2,348305	273	2,436163
174	2,240549	224	2,350248	274	2,437751
175	2,243038	225	2,352183	275	2,439333
176	2,245513	226	2,354108	276	2,440909
177	2,247973	227	2,356026	277	2,442479
178	2,250420	228	2,357935	278	2,444045
179	2,252853	229	2,359835	279	2,445604
180	2,255273	230	2,361728	280	2,447158
181	2,257679	231	2,363612	281	2,448706
182	2,260071	232	2,365488	282	2,450249
183	2,262451	233	2,367356	283	2,451786
184	2,264818	234	2,369216	284	2,453318
185	2,267172	235	2,371068	285	2,454845
186	2,269513	236	2,372912	286	2,456366
187	2,271842	237	2,374748	287	2,457889
188	2,274158	238	2,376577	288	2,459392
189	2,276462	239	2,378398	289	2,460898
190	2,278754	240	2,380211	290	2,462398
191	2,281033	241	2,382017	291	2,463893
192	2,283301	242	2,383815	292	2,465383
193	2,285557	243	2,385606	293	2,466868
194	2,287802	244	2,387389	294	2,468347
195	2,290035	245	2,389166	295	2,469822
196	2,292256	246	2,390935	296	2,471292
197	2,294466	247	2,392697	297	2,472756
198	2,296665	248	2,394452	298	2,474216
199	2,298853	249	2,396199	299	2,475671
200	2,301029	250	2,397940	300	2,477121

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
301	2,478566	351	2,545307	401	2,603144
302	2,480007	352	2,546543	402	2,604116
303	2,481443	353	2,547775	403	2,605305
304	2,482874	354	2,549003	404	2,606381
305	2,484299	355	2,550128	405	2,607455
306	2,485721	356	2,551449	406	2,608526
307	2,487138	357	2,552668	407	2,609594
308	2,488551	358	2,553883	408	2,610660
309	2,489958	359	2,555094	409	2,611723
310	2,491362	360	2,556303	410	2,612784
311	2,492760	361	2,557507	411	2,613842
312	2,494155	362	2,558709	412	2,614897
313	2,495544	363	2,559907	413	2,615950
314	2,496929	364	2,561101	414	2,617000
315	2,498311	365	2,562293	415	2,618048
316	2,499687	366	2,563481	416	2,619093
317	2,501059	367	2,564666	417	2,620136
318	2,502427	368	2,565848	418	2,621176
319	2,503791	369	2,567026	419	2,622214
320	2,505149	370	2,568202	420	2,623249
321	2,506505	371	2,569374	421	2,624282
322	2,507856	372	2,570543	422	2,625312
323	2,509203	373	2,571709	423	2,626340
324	2,510545	374	2,572872	424	2,627366
325	2,511883	375	2,574031	425	2,628389
326	2,513218	376	2,575188	426	2,629409
327	2,514548	377	2,576341	427	2,630428
328	2,515874	378	2,577492	428	2,631444
329	2,517196	379	2,578639	429	2,632457
330	2,518514	380	2,579784	430	2,633468
331	2,519828	381	2,580925	431	2,634477
332	2,521138	382	2,582063	432	2,635484
333	2,522444	383	2,583199	433	2,636488
334	2,523746	384	2,584331	434	2,637489
335	2,525045	385	2,585461	435	2,638489
336	2,526339	386	2,586587	436	2,639486
337	2,527629	387	2,587711	437	2,640481
338	2,528916	388	2,588832	438	2,641475
339	2,530199	389	2,589949	439	2,642465
340	2,531479	390	2,591065	440	2,643453
341	2,532754	391	2,592177	441	2,644439
342	2,534026	392	2,593286	442	2,645422
343	2,535294	393	2,594393	443	2,646404
344	2,536558	394	2,595496	444	2,647383
345	2,537819	395	2,596597	445	2,648360
346	2,539076	396	2,597695	446	2,649335
347	2,540329	397	2,598790	447	2,650308
348	2,541579	398	2,599883	448	2,651278
349	2,542825	399	2,600973	449	2,652246
350	2,544068	400	2,602059	450	2,653213

The Table of Logarithms.

Num.	Logarithm.	Num.	Logarithm.	Num.	Logarithm.
451	2,654177	501	2,699881	551	2,741153
452	2,655138	502	2,700704	552	2,741939
453	2,656098	503	2,701566	553	2,742705
454	2,657056	504	2,702428	554	2,743459
455	2,658011	505	2,703290	555	2,744203
456	2,658965	506	2,704151	556	2,744938
457	2,659916	507	2,705002	557	2,745663
458	2,660865	508	2,705854	558	2,746384
459	2,661813	509	2,706705	559	2,747093
460	2,662758	510	2,707556	560	2,747798
461	2,663701	511	2,708407	561	2,748493
462	2,664642	512	2,709258	562	2,749183
463	2,665581	513	2,710109	563	2,749863
464	2,666518	514	2,710953	564	2,750536
465	2,667453	515	2,711797	565	2,751208
466	2,668386	516	2,712640	566	2,751875
467	2,669317	517	2,713482	567	2,752536
468	2,670246	518	2,714323	568	2,753193
469	2,671173	519	2,715163	569	2,753848
470	2,672098	520	2,716003	570	2,754493
471	2,673021	521	2,716843	571	2,755133
472	2,673942	522	2,717681	572	2,755773
473	2,674861	523	2,718519	573	2,756408
474	2,675778	524	2,719357	574	2,757033
475	2,676694	525	2,720194	575	2,757653
476	2,677607	526	2,721030	576	2,758268
477	2,678518	527	2,721865	577	2,758873
478	2,679428	528	2,722699	578	2,759473
479	2,680336	529	2,723532	579	2,760068
480	2,681241	530	2,724364	580	2,760653
481	2,682144	531	2,725195	581	2,761233
482	2,683047	532	2,726025	582	2,761803
483	2,683947	533	2,726854	583	2,762368
484	2,684845	534	2,727682	584	2,762923
485	2,685742	535	2,728509	585	2,763473
486	2,686636	536	2,729335	586	2,764013
487	2,687529	537	2,730160	587	2,764548
488	2,688419	538	2,730984	588	2,765073
489	2,689309	539	2,731807	589	2,765593
490	2,690196	540	2,732629	590	2,766103
491	2,691081	541	2,733450	591	2,766603
492	2,691965	542	2,734269	592	2,767103
493	2,692847	543	2,735087	593	2,767593
494	2,693727	544	2,735904	594	2,768073
495	2,694605	545	2,736720	595	2,768543
496	2,695482	546	2,737535	596	2,769003
497	2,696356	547	2,738349	597	2,769453
498	2,697229	548	2,739162	598	2,769893
499	2,698101	549	2,739974	599	2,770323
500	2,698970	550	2,740785	600	2,770743

The Table of Logarithms

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
601	2,778874	651	2,813581	701	2,845718
602	2,779596	652	2,814248	702	2,846337
603	2,780317	653	2,814913	703	2,846955
604	2,781037	654	2,815578	704	2,847573
605	2,781751	655	2,816241	705	2,848189
606	2,782473	656	2,816904	706	2,848805
607	2,783189	657	2,817565	707	2,849419
608	2,783904	658	2,818226	708	2,850033
609	2,784617	659	2,818885	709	2,850646
610	2,785329	660	2,819543	710	2,851258
611	2,786041	661	2,820201	711	2,851869
612	2,786751	662	2,820858	712	2,852479
613	2,787460	663	2,821514	713	2,853089
614	2,788164	664	2,822168	714	2,853698
615	2,788875	665	2,822822	715	2,854306
616	2,789581	666	2,823474	716	2,854913
617	2,790285	667	2,824126	717	2,855519
618	2,790988	668	2,824776	718	2,856124
619	2,791691	669	2,825426	719	2,856729
620	2,792392	670	2,826075	720	2,857332
621	2,793093	671	2,826723	721	2,857935
622	2,793791	672	2,827369	722	2,858537
623	2,794488	673	2,828015	723	2,859138
624	2,795185	674	2,828659	724	2,859739
625	2,795880	675	2,829304	725	2,860338
626	2,796574	676	2,829947	726	2,860937
627	2,797268	677	2,830589	727	2,861534
628	2,797959	678	2,831229	728	2,862131
629	2,798651	679	2,831869	729	2,862728
630	2,799341	680	2,832509	730	2,863323
631	2,800039	681	2,833147	731	2,863917
632	2,800717	682	2,833784	732	2,864511
633	2,801404	683	2,834421	733	2,865104
634	2,802089	684	2,835056	734	2,865696
635	2,802774	685	2,835691	735	2,866287
636	2,803457	686	2,836324	736	2,866878
637	2,804139	687	2,836957	737	2,867467
638	2,804821	688	2,837588	738	2,868056
639	2,805501	689	2,838219	739	2,868643
640	2,806179	690	2,838849	740	2,869232
641	2,806858	691	2,839478	741	2,869818
642	2,807535	692	2,840106	742	2,870404
643	2,808211	693	2,840733	743	2,870989
644	2,808886	694	2,841359	744	2,871573
645	2,809559	695	2,841985	745	2,872156
646	2,810233	696	2,842609	746	2,872739
647	2,810904	697	2,843233	747	2,873321
648	2,811575	698	2,843855	748	2,873902
649	2,812245	699	2,844477	749	2,874482
650	2,812913	700	2,845098	750	2,875061

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
751	2,875639	801	2,903633	851	2,919919
752	2,876218	802	2,904174	852	2,920439
753	2,876795	803	2,904716	853	2,920949
754	2,877371	804	2,905256	854	2,921458
755	2,877947	805	2,905796	855	2,921966
756	2,878522	806	2,906335	856	2,922474
757	2,879096	807	2,906874	857	2,922981
758	2,879669	808	2,907411	858	2,923487
759	2,880242	809	2,907949	859	2,923993
760	2,880814	810	2,908485	860	2,924498
761	2,881385	811	2,909021	861	2,925003
762	2,881955	812	2,909556	862	2,925507
763	2,882525	813	2,910091	863	2,926011
764	2,883093	814	2,910624	864	2,926514
765	2,883661	815	2,911158	865	2,927016
766	2,884229	816	2,911690	866	2,927518
767	2,884795	817	2,912219	867	2,928019
768	2,885361	818	2,912773	868	2,928519
769	2,885926	819	2,913284	869	2,929019
770	2,886491	820	2,913814	870	2,929519
771	2,887054	821	2,914343	871	2,930018
772	2,887617	822	2,914872	872	2,930516
773	2,888179	823	2,915399	873	2,931014
774	2,888741	824	2,915927	874	2,931511
775	2,889302	825	2,916454	875	2,932008
776	2,889862	826	2,916980	876	2,932504
777	2,890421	827	2,917506	877	2,932999
778	2,890979	828	2,918030	878	2,933495
779	2,891537	829	2,918555	879	2,933989
780	2,892095	830	2,919078	880	2,934483
781	2,892651	831	2,919601	881	2,934976
782	2,893207	832	2,920123	882	2,935468
783	2,893762	833	2,920645	883	2,935961
784	2,894316	834	2,921166	884	2,936453
785	2,894869	835	2,921686	885	2,936943
786	2,895423	836	2,922206	886	2,937434
787	2,895975	837	2,922725	887	2,937924
788	2,896526	838	2,923244	888	2,938415
789	2,897077	839	2,923762	889	2,938902
790	2,897627	840	2,924279	890	2,939390
791	2,898176	841	2,924796	891	2,939878
792	2,898725	842	2,925312	892	2,940365
793	2,899273	843	2,925825	893	2,940851
794	2,899821	844	2,926342	894	2,941338
795	2,900367	845	2,926857	895	2,941823
796	2,900913	846	2,927370	896	2,942308
797	2,901458	847	2,927883	897	2,942792
798	2,902003	848	2,928396	898	2,943276
799	2,902547	849	2,928908	899	2,943759
800	2,903089	850	2,929419	900	2,944243

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
901	2,954725	935	2,970822	968	2,985875
902	2,955207	936	2,971276	969	2,986324
903	2,955688	937	2,971739	970	2,986772
904	2,956168	938	2,972203	971	2,987219
905	2,956640	939	2,972666	972	2,987666
906	2,957128	940	2,973128	973	2,988113
907	2,957607	941	2,973589	974	2,988559
908	2,958086	942	2,974050	975	2,989005
909	2,958564	943	2,974512	976	2,989449
910	2,959041	944	2,974972	977	2,989895
911	2,959518	945	2,975432	978	2,990339
912	2,959995	946	2,975891	979	2,990783
913	2,960471	947	2,976349	980	2,991226
914	2,960946	948	2,976808	981	2,991669
915	2,961421	949	2,977266	982	2,992111
916	2,961895	950	2,977724	983	2,992554
917	2,962369	951	2,978181	984	2,992995
918	2,962842	952	2,978637	985	2,993436
919	2,963315	953	2,979093	986	2,993877
920	2,963788	954	2,979548	987	2,994317
921	2,964259	955	2,980003	988	2,994756
922	2,964731	956	2,980458	989	2,995196
923	2,965202	957	2,980912	990	2,995635
924	2,965672	958	2,981366	991	2,996074
925	2,966142	959	2,981819	992	2,996512
926	2,966611	960	2,982271	993	2,996949
927	2,967079	961	2,982723	994	2,997386
928	2,967548	962	2,983175	995	2,997823
929	2,968016	963	2,983626	996	2,998259
930	2,968483	964	2,984077	997	2,998695
931	2,968949	965	2,984527	998	2,999133
932	2,969416	966	2,984977	999	2,999565
933	2,969882	967	2,985426	1000	3,000000
934	2,970347				

CHAP.

CHAP. III.

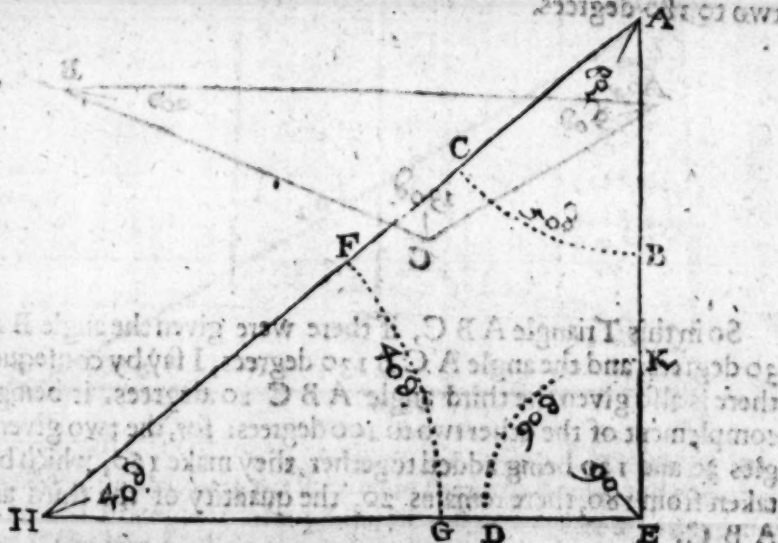
*The use of the Tables of Sines and Logarithms in
the resolving of Plain Triangles.*

Before I come to shew how the quantity of the sides and angles of any Triangle may be found by help of the former Tables, it will be convenient first to deliver these following considerations and Theoremes, as necessities thereunto.

I. A Triangle is a figure consisting of three sides and three angles, as is the figure ABC .

2. Any two sides of a Triangle are called the sides of the angle comprehended by them, as the sides AB and AC are the sides containing the angle CAB .

3. The measure of an An-A gle, is the quantity of an arch of a Circle described on the angular point, and cutting both the containing sides of the same angle: as in the Triangle following, the arch C B, is the measure of the angle at A; the arch K D is the measure of the angle at E; and the arch F G is the measure of the angle at H; each of these arches are described on the angular points A, H, E, and cut the containing sides.



4. A Degree is the $\frac{1}{360}$ part of any Circle

5. A Semicircle contains 180 degrees.

6. A Quadrant containeth 90 degrees.

7. The complement of an angle lesse then a Quadrant, is so much as that angle wanteth of 90 degrees, as if the angle H A E should contain 50 degrees, the complement thereof would be 40 degrees, for if you take 50 from 90 there will remain 40. 8. The

8. The

8. The complement of an angle to a Semicircle, is the remainder thereof to 180 degrees.

9. An angle is either Right, Acute, or Obtuse.

10. A Right angle is that whose measure is a Quadrant.

11. An Acute angle is less than a right angle.

12. An Obtuse angle is greater than a Quadrant.

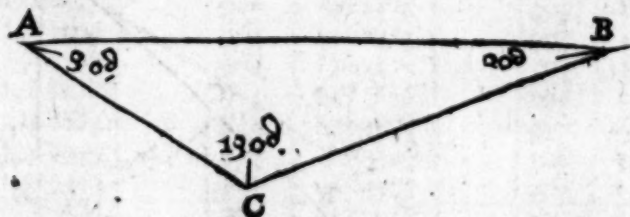
13. A Triangle is either Right angled, or Oblique angled.

14. A Right angled Triangle is that which hath one right angle, as the Triangle A H E is right angled at E.

15. In every right angled Triangle, that side which subtendeth or lieth opposite to the right angle, is called the Hypotenuse, and of the other two sides, the one is called the Perpendicular, and the other the Base, at pleasure, but most commonly the shortest is called the Perpendicular, and the longer is called the Base. So in the former Triangle, the side A H is the Hypotenuse, H E the Base, and A E the Perpendicular.

16. In every right angled Triangle, if you have one of the acute angles given, the other is also given, it being the complement thereof to 90 degrees. As in the Triangle A H E, suppose there were given the angle A H E 40 degrees, then by consequence the angle H A E must be 50 degrees, which is the complement of the other to 90 degrees.

17. The three angles of any right lined Triangle whatsoever, are equal to two right angles, or to 180 degrees: so that if in any right lined Triangle, you have any two of the angles given, you have the third angle also given, it being the complement of the other two to 180 degrees.



So in this Triangle A B C, if there were given the angle B A C 30 degrees, and the angle A C B 130 degrees, I say by consequence there is also given the third angle A B C 20 degrees. it being the complement of the other two to 180 degrees: for, the two given angles 30 and 130 being added together, they make 160, which being taken from 180, there remains 20, the quantity of the third angle A B C.

18. In all plain Triangles whatsoever, the sides are in proportion one to the other, as the Sines of the angles opposite to those sides. So in the Triangle A B C, the Sine of the angle A C B, is in such proportion to the side A B, as the Sine of the angle C A B is to the side B C, and so of any other.

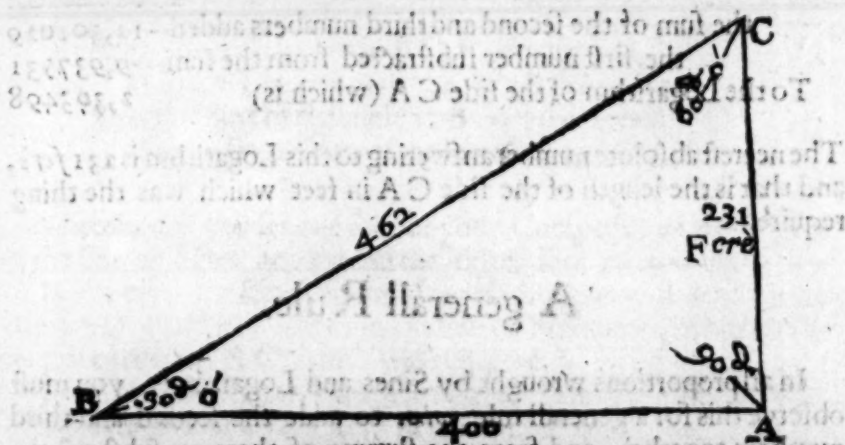
CHAP. IV.

Containing the doctrine of the dimension of right lined Triangles, whether right angled or oblique angled, and the severall Cases therein resolved, both by Tables, and Lines of Artificiall Numbers, Sines, and Tangents.



Having in the foregoing Chapters of this Book explained and shewed the use of the Tables of Sines and Logarithms. and also delivered divers necessary Theorems relating to the mensuration of plain Triangles, I come now to shew how a plain Triangle may be resolved, that is, by having any three of the six parts of a plain Triangle given, to finde a fourth, both by the Tables of Sines and Logarithms, and also by the lines of Artificiall Numbers, Sines and Tangents on the Index of your Table, so that when your Tables are not ready at hand, you may make use of these Lines, which will sufficiently supply the want of them.

In all the cases following, I have made use but of two Triangles for Examples, one right angled, and the other oblique angled, but in either of them I have expressed all the varieties that are necessary, so that any three parts being given in any of them, a fourth may be found at pleasure.



The severall cases of the right angled Triangle will best be applied in the taking of heights, as is shewed in the next Book, and the oblique angled Triangle for the taking of distances there also taught, so that if the line C A in the right angled Triangle were a Tree, Tower, or Steeple, and that you would know the height thereof, you must observe with your Instrument the angle C B A, and measure the distance B A, so have you in the right angled Triangle A B C the Base A B, and the angle at the Base C B A, then may you (by the 1. Case) finde the side C A, which is the height of the thing required.

8. The complement of an angle to a Semicircle, is the remainder thereof to 180 degrees.

9. An angle is either Right, Acute, or Obtuse.

10. A Right angle is that whose measure is a Quadrant.

11. An Acute angle is lesse then a right angle.

12. An Obtuse angle is greater then a Quadrant.

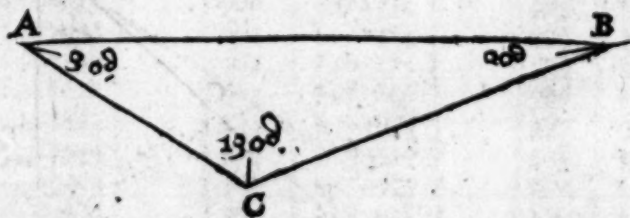
13. A Triangle is either Right angled, or Oblique angled.

14. A Right angled Triangle is that which hath one right angle, as the Triangle A H E is right angled at E.

15. In every right angled Triangle, that side which subtendeth or lieth opposite to the right angle, is called the Hypothenufall, and of the other two sides, the one is called the Perpendicular, and the other the Base, at pleasure, but most commonly the shortest is called the Perpendicular, and the longer is called the Base. So in the former Triangle, the side A H is the Hypothenufall, H E the Base, and A E the Perpendicular.

16. In every right angled Triangle, if you have one of the acute angles given, the other is also given, it being the complement thereof to 90 degrees. As in the Triangle A H E, suppose there were given the angle A H E 40 degrees, then by consequence the angle H A E must be 50 degrees, which is the complement of the other to 90 degrees.

17. The three angles of any right lined Triangle whatsoever, are equal to two right angles, or to 180 degrees: so that if in any right lined Triangle, you have any two of the angles given, you have the third angle also given, it being the complement of the other two to 180 degrees.



So in this Triangle A B C, if there were given the angle B A C 30 degrees, and the angle A C B 130 degrees, I say by consequence there is also given the third angle A B C 20 degrees. it being the complement of the other two to 180 degrees: for, the two given angles 30 and 130 being added together, they make 160, which being taken from 180, there remains 20, the quantity of the third angle A B C.

18. In all plain Triangles whatsoever, the sides are in proportion one to the other, as the Sines of the angles opposite to those sides. So in the Triangle A B C, the Sine of the angle A C B, is in such proportion to the side A B, as the Sine of the angle C A B is to the side B C, and so of any other.

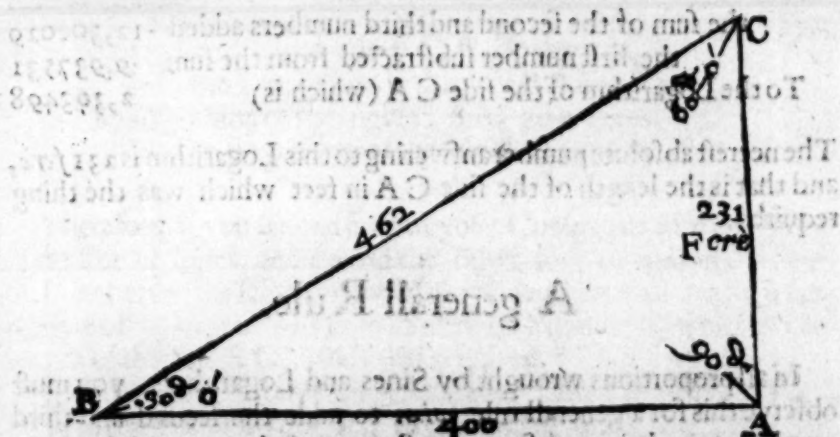
CHAP. IV.

Containing the doctrine of the dimension of right lined Triangles, whether right angled or oblique angled, and the severall Cases therein resolved, both by Tables, and Lines of Artificiall Numbers, Sines, and Tangents.



Having in the foregoing Chapters of this Book explained and shewed the use of the Tables of Sines and Logarithms. and also delivered divers necessary Theorems relating to the mensuration of plain Triangles, I come now to shew how a plain Triangle may be resolved, that is, by having any three of the six parts of a plain Triangle given, to finde a fourth, both by the Tables of Sines and Logarithms, and also by the lines of Artificiall Numbers, Sines and Tangents on the Index of your Table, so that when your Tables are not ready at hand, you may make use of these Lines, which will sufficiently supply the want of them.

In all the cases following, I have made use but of two Triangles for Examples, one right angled, and the other oblique angled, but in either of them I have expressed all the varieties that are necessary, so that any three parts being given in any of them, a fourth may be found at pleasure.



The severall cases of the right angled Triangle will best be applied in the taking of heights, as is shewed in the next Book; and the oblique angled Triangle for the taking of distances there also taught; so that if the line CA in the right angled Triangle were a Tree, Tower, or Steeple, and that you would know the height thereof, you must observe with your Instrument the angle CBA, and measure the distance BA; so have you in the right angled Triangle ABC the Base AB, and the angle at the Base CBA, then may you (by the 1. Case) finde the side CA, which is the height of the thing required.

In the resolving of plain Triangles, there are severall Cases, of which, I will only insist on those that have most relation to the work in hand. And first,

Of Right angled plain Triangles.

CASE I.

In a right angled plain Triangle, the Base and the angle at the Base being given, to finde the Perpendicular.

IN the right angled Triangle following A B C, there is given, the Base thereof B A, 400 foot, and the angle at the Base C B A 30 degrees, and it is required to finde the perpendicular C A.

Now because the angle C B A is given, the angle B C A is also given; it being the complement of the other to 90 degrees; and therefore the angle B C A is 60 degrees. Then to finde the perpendicular C A, the proportion is,

As the Sine of the angle B C A, 60 degrees (which is) 9,937531

Is to the Logarithm of the side B A, 400 foot (which is) 2,602059

So is the sine of the angle C B A 30 degrees (which is) 9,698970

the sum of the second and third numbers added-- 12,301029

the first number subtracted from the sum-- 9,937531

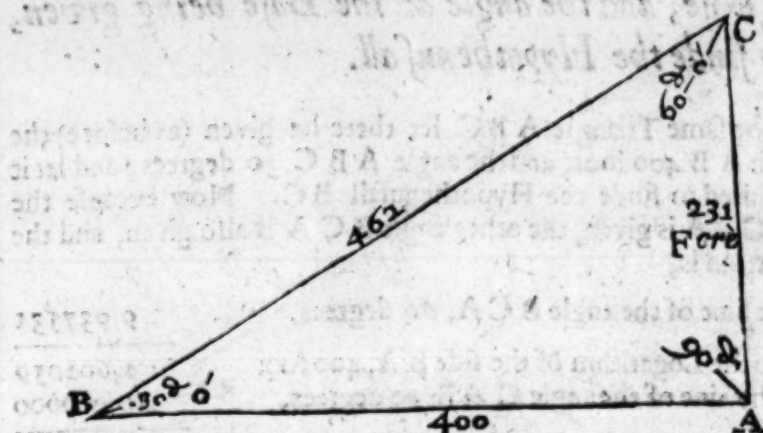
To the Logarithm of the side C A (which is) 2,363498

The neereſt absolute number answering to this Logarithm is 231 feet, and that is the length of the side C A in feet which was the thing required.

A generall Rule.

In all proportions wrought by Sines and Logarithms, you must observe this for a generall rule, *viz.* to adde the second and third numbers together, and from the summe of them to subtract the first number, so shall the remainder answer your question demanded, as by the former work you may perceive; where the Logarithm of the side B A 2,602059 (which is the second term) is added to the sine of the angle C B A 9,698970, (which is the third term) and from the summe of them (namely from 12,301029) is subtracted 9,937531, the sine of the angle B C A, which is the first number, and there remaineth, 2,363498, which is the Logarithm of 231 almost, and that is the length of the side required in feet.

The same manner of work is to be observed in all the Cases following as will plainly appear.



How to perform the same work, by the lines of Sines and Numbers.

These kinde of proportions are wrought more easily by help of the lines of artificiall Numbers, Sines and Tangents on the Index of your Table, and exact enough for any ordinary occasion, for the proportion being,

As the sine of the angle B C A, 60 degrees,
Is to the Logarithm of the side B A 400 feet,
So is the Sine of the angle C B A, 30 degrees,
To the Logarithm of the side A C 231 feet, *ferè*.

Therefore, if you set one foot of your Compasses at 60 degrees in the line of Sines, and extend the other foot to 400 in the line of Numbers, the same extent of the Compasses will reach from the sine of 30 degrees to 231 in the line of Numbers, which is the length of the side A C, which was required.

Or otherwise, Extend the Compasses from the sine of 30 degrees to the sine of 60 degrees, in the line of Sines, the same extent will also reach from 400, in the line of Numbers, to 231 as before. And thus by these Artificiall Lines, the work is much abbreviated, there being need neither of pen, inke, paper or Tables, but only of your Compasses.

CASE II.

*The Base, and the angle at the Base being given,
to finde the Hypothenufall.*

IN the same Triangle A B C let there be given (as before) the Base A B 400 foot, and the angle A B C 30 degrees, and let it be required to finde the Hypothenufall B C. Now because the angle C B A is given, the other angle B C A is also given, and the proportion is,

As the Sine of the angle B C A, 60 degrees,	9,937531
Is to the Logarithm of the side B A, 400 foot	2,602059
So is the Sine of the angle C A B, 90 degrees,	10,000000

the sum of the second and third numbers added--12,602059
the first number subtracted from the sum--9,937531

To the Logarithm of the side B C: which is, 2,665428

The absolute number answering to this Logarithm is 462, and so many feet is the Hypothenufall B C.

By the lines of Sines and Numbers.

The manner of work is altogether the same with the former, for the proportion being,

As the Sine of the angle B C A 60 degrees,
Is to the length of the side B A 400 foot;
So is the sine of the angle C A B 90 degrees,
To the length of the side C B 462.

Extend the Compasses from the sine of 60 degrees to 400 in the line of Numbers, the same extent will reach from the Sine of 90 degrees to 462 in the line of Numbers, and that is the length of the side B C.

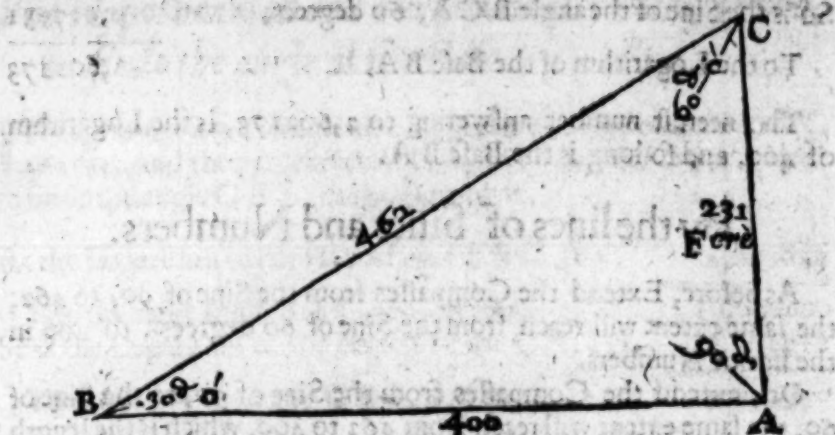
Or you may extend the Compasses from the Sine of 60 degrees to the Sine of 90 degrees; the same extent will also reach from 400 to 462, as before.

CASE III.

*The Hypothenufall, and angle at the Base being
given, to finde the Perpendicular.*

IN the same Triangle, let there be given the Hypothenufall B C 462 feet, and the angle at the Base C B A 30 degrees, to finde the perpendicular C A.

The angle C A B is a right angle or 90 degrees, therefore the proportion is,



As the Sine of the angle C A B 90 degrees,	10,000000
Isto the Logarithme of the side B C 462,	2,664642
So is the Sine of the angle C B A 30 degrees,	9,698970
To the Logarithme of the side C A.	12,363612

The number answering to this Logarithme is 231 *ferè*, and that is the length of the side C A in feet.

Here the Work is somewhat abbreviated, for the angle C A B being a right angle, and being the first term, when the second and third terms are added together, the first is easily subtracted from it by cancelling the figure next your left hand, as you see in the example; and so the rest of that number is the Logarithme of the number sought.

By the lines of Sines and Numbers.

Extend the Compasses from the Sine of 90 degrees to 462, the same extent will reach from the Sine of 30 degrees to 231.

Or extend the Compasses from the Sine of 90 degrees to the Sine of 30 degrees, the same extent will reach from 462 to 231; and that is the side C A.

CASE IV,

The Hypothensall, and angle at the Base being given, to finde the Base

L Et there be given in the former Triangle the Hypothensall B C, and the angle at the Base C B A, and by consequence the angle B C A the complement of the other to 90; then to finde B A, the proportion is,

A₅

CASE II.

*The Base, and the angle at the Base being given,
to finde the Hypothenusall.*

IN the same Triangle ABC let there be given (as before) the Base AB 400 foot, and the angle ABC 30 degrees, and let it be required to finde the Hypothenusall BC . Now because the angle CBA is given, the other angle BCA is also given, and the proportion is,

As the Sine of the angle BCA , 60 degrees,	9,937531
Is to the Logarithm of the side BA , 400 foot	2,602059
So is the Sine of the angle CAB , 90 degrees,	10,000000

the sum of the second and third numbers added--12,602059
the first number subtracted from the sum--9,937531

To the Logarithm of the side BC ; which is,	2,665428
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The absolute number answering to this Logarithm is 462, and so many feet is the Hypothenusall BC .

By the lines of Sines and Numbers.

The manner of work is altogether the same with the former, for the proportion being,

As the Sine of the angle BCA 60 degrees,	
Is to the length of the side BA 400 foot,	
So is the sine of the angle CAB 90 degrees,	
To the length of the side CB 462.	

Extend the Compasses from the sine of 60 degrees to 400 in the line of Numbers, the same extent will reach from the Sine of 90 degrees to 462 in the line of Numbers, and that is the length of the side BC .

Or you may extend the Compasses from the Sine of 60 degrees to the Sine of 90 degrees; the same extent will also reach from 400 to 462, as before.

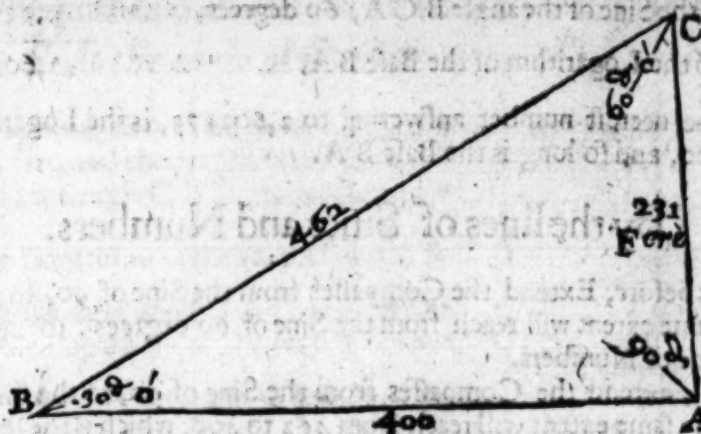
CASE III.

*The Hypothenusall, and angle at the Base being
given, to finde the Perpendicular.*

IN the same Triangle, let there be given the Hypothenusall BC 462 feet, and the angle at the Base CBA 30 degrees, to finde the perpendicular CA .

The

The angle C A B is a right angle or 90 degrees, therefore the proportion is,



As the Sine of the angle C A B 90 degrees,	10,000000
Isto the Logarithme of the side B C 462,	2,664642
So is the Sine of the angle C B A 30 degrees,	9,698970
To the Logarithme of the side C A.	12,363612

The number answering to this Logarithme is 231 *ferè*, and that is the length of the side C A in feet.

Here the Work is somewhat abbreviated, for the angle C A B being a right angle, and being the first term, when the second and third terms are added together, the first is easily subtracted from it by cancelling the figure next your left hand, as you see in the example; and so the rest of that number is the Logarithme of the number sought.

By the lines of Sines and Numbers.

Extend the Compasses from the Sine of 90 degrees to 462, the same extent will reach from the Sine of 30 degrees to 231.

Or extend the Compasses from the Sine of 90 degrees to the Sine of 30 degrees, the same extent will reach from 462 to 231; and that is the side C A.

CASE IV,

The Hypothensall, and angle at the Base being given, to finde the Base

L Et there be given in the former Triangle the Hypothensal B C, and the angle at the Base C B A, and by consequence the angle B C A the complement of the other to 90; then to finde B A, the proportion is,

As

As the Sine of the angle C A B, 90 degrees	10,000000
Is to the Hypothenufall B C, 462	2,664642
So is the Sine of the angle B C A, 60 degrees,	9,937531
To the Logarithm of the Base B A,	2,602173

The nearest number answering to 2,602173, is the Logarithm of 400, and so long is the Base B A.

By the lines of Sines and Numbers.

As before, Extend the Compasses from the Sine of 90, to 462, the same extent will reach from the Sine of 60 degrees, to 400 in the line of Numbers.

Or, extend the Compasses from the Sine of 90, to the Sine of 60, the same extent will reach from 462 to 400, which is the length of the Base B A.

CASE V.

The Perpendicular, and angle at the Base being given, to finde the Hypothenufall.

IF the Perpendicular C A be given 231, and the angle at the Base C B A 30 degrees, the Hypothenufall B C may be found thus, for,

As the Sine of the angle C B A, 30 degrees,	9,698970
Is to the Logarithm of the Perpendicular C A 231	12,363612
So is the Sine of the angle C A B, 90 degrees,	10,000000
To the Logarithm of the Hypothenufall B C	2,664642

¶ Here, because the angle C A B is a right angle, or 90 degrees, and comes in the third place, I therefore only put an unite before the second term, and from that second term subtract the first term, and the remainder is 2,664642, the absolute number answering thereunto is 462, the side B C.

By the lines of Sines and Numbers.

Extend the Compasses from the Sine of 30 degrees, to 231, the same extent will reach from the sine of 90 degrees to 462.

Or, the distance between the Sine of 30 degrees and 90 degrees, will be equall to the distance between 231, and 462, which giveth the side required.

CASE VI.

*The Hypothenuſall and Perpendicular being given,
to finde the angle at the Baſe.*

IN the foregoing Triangle there is given the Hypothenuſall B C 462 feet, and the perpendicular C A, 231 feet, and it is required to finde the angle C B A, the proportion is,

As the Logarithm of the Hypothenuſall B C 462	2,661642
Iſto the right angle B A C, 90 degrees,	10,000000
So is the Logarithm of the perpendicular C A, 231,	12,363612
To the ſine of the angle C B A, 30 degrees.	9,698970

By the lines of Sines and Numbers.

Extend the Compaſſes from 462, to the ſine of 90, the ſame extent will reach from 231 to the ſine of 30 degrees.

Or, Extend the Compaſſes from 462 to 231, the ſame extent will reach from the ſine of 90 degrees, to the Sine of 30 degrees, which is the quantity of the enquired angle C B A.

Of Oblique angled plain Triangles.

CASE VII.

Having two angles, and a ſide oppoſite to one of them given, to finde the ſide oppoſite to the other.

IN the Triangle Q R S, there is given the angle Q S R 24 degrees 20 minutes; and the angle Q R S 45 degrees 10 minutes, and the ſide Q S 303 feet, and it is required to finde the ſide Q R.

¶ Here note, that in oblique angled plain Triangles, as well as in Right angled, the ſides are in proportion one to the other, as the ſines of the angles oppoſite to thoſe ſides. Therefore,

As the ſine of the angle Q R S 45 deg. 10 min.

9,850745

Iſto the Logarithm of the ſide Q S 303 feet,

2,481443

So is the ſine of the angle Q S R 24 degrees 20 min.

9,614944

the ſum of the ſecond and third terms--12,096387

the firſt term ſubſtracted--9,850745

To the Logarithme of the ſide Q R,

2,245642

The neereſt abſolute number anſwering to this Logarithm is 176, and ſo many feet is the ſide Q R.

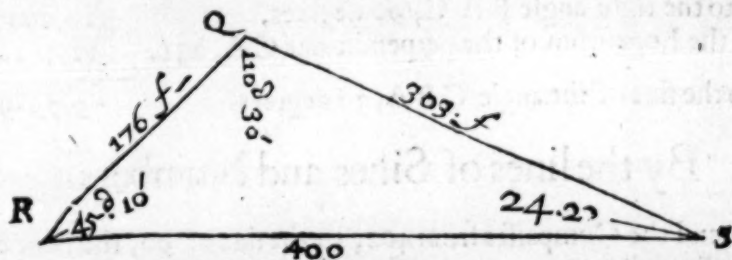
By

By the lines of Sines and Numbers.

The lines of Sines and Numbers will resolve these Triangles by the same manner of work as in the other before. For,

If you extend the Compasses from the sine of 45 degrees 10 min. to 303, the same extent will reach from the sine of 24 degrees 20 minutes, to 176, and so much is the side Q R.

Or, Extend the Compasses from the Sine of 45 degrees 10 min. to 24 degrees 20 minutes, the same extent will reach from 303, to 176, the length of the inquired side.



In like manner, if the angle R Q S 110 degrees 30 minutes, and the angle Q R S 45 degrees 10 min. and the side Q S 303 feet, had been given, and the side R S required, the manner of work had been the same ; for,

As the sine of the angle Q R S 45 degrees 10 min. 9,850745

Is to the Logarithm of the side Q S 303 feet, 2,481443
 So is the sine of R Q S 110 deg. 30 min. (or 69 deg. 30 m.) 9,971588

the sum of the second and third terms--12,453031
 the first term subtracted--9,850745

To the Logarithm of the side R S, 2,602286

The absolute number answering to this Logarithm is 400, and so much is the side R S.

☞ In this case, because the angle R Q S is more then 90 degrees, you must therefore take the complement thereof to 180 degrees, so 110 degrees 30 minutes, being taken from 180 degrees, there remains 69 degrees 30 min. whose Sine is the same with 110 deg. 30 min. and being used in stead thereof, will effect the same thing.

By the lines of Sines and Numbers.

Extend the Compasses from the Sine of 45 degrees 10 min. to 303, the same extent will reach from the sine of 69 deg. 30 min. to 400. which is the side R S required.

Or

Or the Compasses being opened to the distance between the sine of 45 deg. 10 min. and 69 deg. 30 min. the same distance will reach from 303 to 400 as before.

CASE VIII.

Two sides and an angle opposite to one of them being given, to finde the angle opposite to the other.

IN the same Triangle, let there be given, the side QS 303, and QR 176, together with the angle QSR 24 degrees 20 minutes, and let it be required to finde the angle QRS, the proportion is,

As the Logarithm of the side QR 176, 2,245513

Is to the sine of the angle QSR, 24 deg. 20 min. 9,614944

So is the Logarithm of the side QS 303, 2,481443

the sum of the second and third numbers--12,096387

the first number subtracted from the sum--7,245513

To the sine of the angle QRS, 9,850374

The nearest degree answering to this sine is 45 degrees 10 min. which is the quantity of the angle QRS, required.

By the lines of Sines and Numbers.

Extend the Compasses from 176, to the sine of 24 degrees 20 minutes, the same extent will reach from 303 to 45 deg. 10 min. the angle QRS.

Or, the distance between 176 and 303, will be equall to the distance between 24 degrees 20 minutes, and 45 deg. 10 min.

CASE IX.

Having two sides, and the angle contained by them given, to finde either of the other angles.

THIS Case will seldome come in use in Surveying, because the thing required is an angle, which are most commonly given, they being observed by Instrument, and therefore in this place may be omitted, partly because the proposition is not wrought by Sines and Logarithms, but by Tangents and Logarithms, and there is no Tables of Tangents in this Book, to work the proportion by: Yet those that are desirous to resolve all kinde of Triangles by the proportionall lines, may have added to the lines of artificiall sines and Numbers. a line of artificiall Tangents, and these three lines to-

M

gether

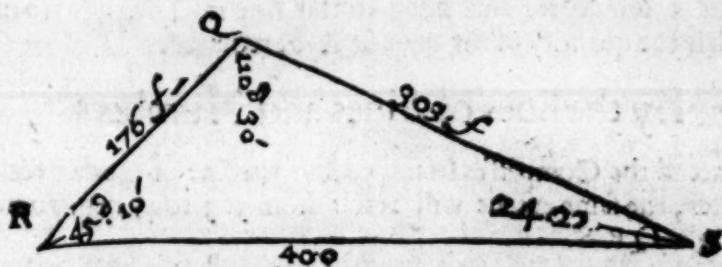
gether, will resolve all Cases in Sphericall, as well as in plain Triangles.

For the performance of this Probleme, suppose there were given the side QS 303, and the side RQ 176, and the angle comprehended by them; namely, the angle RQS 110 degrees 30 minutes, and it were required to finde either of the other angles.

First, Take the summe and difference of the two given sides, their summe is 479, and their difference is 127. Then knowing that the three angles of all right lined Triangles are equal to two right angles or 180 degrees, (*by the 17. Theor. of Chap. 3.*) therefore the angle RQS being 110 degrees 30 minutes, if you subtract this angle from 180 degrees, the remainder will be 69 deg. 30 min. which is the summe of the two unknown angles at R and S , the halfe whereof is 34 deg. 45 min.

The side QS ,	303
The side RQ ,	176
<hr/>	
The summe of the sides,	479
The difference of the sides	127

The halfe sum of the two unknown angles 34 deg. 45 min.



The summe and difference of the sides being thus found, and also the halfe summe of the two unknown angles, the proportion by which you must finde the angles severally is,

As the Logarithm of the summe of the sides, 479,	2,680335
Is to the Logarithm of the difference of the sides, 127,	2,103804
So is the Tangent of the halfe summe of the two unknown angles 34 degrees, 45 minutes,	9,841187
<hr/>	
the summe of the second and third numbers—	11,944991
the first number subtracted—	2,680335
<hr/>	
To the Tangent of 10 degrees 25 minutes,	9,264656

These

These 10 degrees 25 minutes, being added to the halfe summe of the two unknown angles, namely, to 34 degrees 45 minutes, the summe will be 45 degrees 10 minutes, the quantity of the angle QRS, which is the greater angle of the two: Also, these 10 degrees 25 minutes, being subtracted from the same halfe sum, there remaineth 24 degrees 20 minutes for the angle QSR, which is the lesser of the unknown angles: and thus are either of the enquired angles easily found.

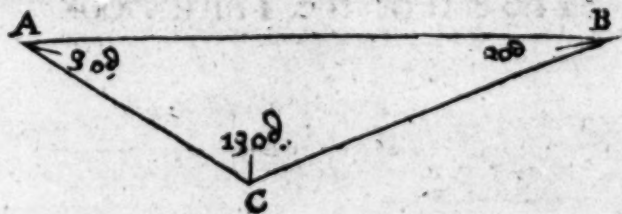
By the lines of Tangents and Numbers.

Extend the Compasses from the summe of the sides 479, to the difference of the sides 127, the same extent upon the line of Tangents will reach from the Tangent of 34 degrees 45 minutes (which is the halfe summe of the two unknown angles) to the Tangent of 10 degrees 25 minutes, and these 10 degrees 25 minutes, added to, and subtracted from the halfe summe, as before is shewed, will give the quantity of either of the two unknown angles.

CASE X.

The three sides of a right lined plain Triangle being given, how to finde the Area, or the superficial content thereof.

First, Adde the three sides together, and from the halfe summe subtract each side severally, to the end you may have the difference betwixt that halfe summe and each side: this done, adde



the Logarithms of the said halfe summe, and of those differences together: and lastly, dividing the summe of those Logarithms by 2, you have the Logarithm of the superficial content or area of the Triangle.

EXAMPLE.

Let the Triangle given be ABC, the sides thereof being 20, 13, 11, how much is the superficial content thereof?

M 2

The

The summe of the sides is 44, the halfe summe is 22, the differences betwixt each side and that halfe are 3, 9, 11, which numbers rank in this order following.

The halfe summe	22	1,342423
The differences,	3	0,301030
	9	0,954243
	11	1,041393
		<hr/>
The summe of the Logarithms		3,639089
The Area. or Content required, 66.		1,819544

And this Area, or superficial Content thus found, is alwayes of the same nature with the sides of the Triangle, that is to say, if the sides of the Triangle be given in feet, then is the content found in feet; also, if the sides be Perches, you shall have the content in perches, and so of any other measure whatsoever. I might add hereunto divers other Cases, but in this place at present let these suffice.

(. . .)

The end of the Third Book.



THE COMPLEAT SURVEYOR.

The Fourth Book.

THE ARGUMENT.



Mr. businelle hitherto hath been to provide necessary Instruments and to learn such things which of necessity ought to be known before we enter the Fields to Sur-

vey. Being thus provided we come now to apply them severall wayes: First, in taking of Heights and Distances whether accessible or in-accessible; and then in Surveying of Land. In this Book every kinde of work is performed

three severall wayes, by three severall *Instruments*, viz. the *Plain Table*, the *Theodolite*, and *Circumferentor*, by which the congruity and harmony of the severall *Instruments* may be easily discerned, and the truth of every *Example* may the better appear. Here is also divers wayes of *Surveying* by one and the same *Instrument*, that is, to take the *Plot* of a *Field* severall wayes, and to measure all kinde of *Grounds* whatsoever, whether *Woodland* or other. Here is also shewn how to take the *Plot* of a whole *Mannor*, and to keepe your *account* in your *Field-Book* after the best and most easiest manner: with divers *Rules*, *Cautions*, and *Directions*, throughout the whole *Book* inserted.

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In this Book every kinde of work is performed



THE
APPLICATION AND VSE
of the severall Instruments (before described)
in the practise of
SURVEYING.

CHAP. I.

Of the use of the Scale.



Having before described the severall Instruments belonging to Surveying, I will now shew the use of them: and first, of the Scale. The Scale is principally intended for the laying out of lines, for which purpose the severall Scales of equal parts are there divided, some of greater and some of lesser quantities: the uses of all the lines being the same, for each line is divided into 11 equall parts, representing 11 Chains, and these grand divisions are numbered with Arithmetical Figures by 1, 2, 3, &c. to 10, then the uppermost large division is again divided into ten other smaller parts, each part containing 10 links of your Chain, each of which smaller parts you may suppose to be again divided into ten other lesser parts, representing single Links of your Chain.

1. *Any length being measured by your Chain, how to lay down the same distance upon paper.*

Suppose, that measuring along a hedge with your Chain, you finde the length thereof to contain 5 Chains 60 Links: Now to take this distance from your Scale, and lay it down upon paper, do thus. First, Draw a line as A B, then place one foot of your Compasses upon your Scale at the figure 5, for your five Chains, and

extend the other foot to fix of the small divisions (which represents the 60 Links) then set this distance upon the line drawn from A to B, so shall the line A B contain 5 Chains 60 Links, if you take the distance from the Scale of 10 in an Inch.

But if you would have your line shorter, and yet to contain 5 Chains 60 Links, then take your distance from a smaller Scale, as of 12, 16, 20, or 24 in an Inch, so shall the 5 Chains 60 Links end at C, if taken from the Scale of 12 in an inch, or at D, by the Scale of 16, or at E by the Scale of 24: either of which lines will contain 5 Chains 60 Links, and be in proportion one to the other as the Scales from whence they were taken. And in this manner may any number of Chains and Links be taken from any of the Scales.

2. *A right line being given, to finde how many Chains and Links are therein contained, according to any Scale assigned.*

Suppose A B were a line given, and it were required to finde how many Chains and Links are contained therein, according to the Scale of 10 in an inch. Take in your Compasses the length of the line A B, and applying it to your Scale of 10 in an Inch, you shall finde the extent of the Compasses to reach from 5 of the great divisions to fix of the lesser divisions, wherefore the line A B contains 5 Chains and 60 Links: The like must be done for any other line, and also by any of the other Scales.

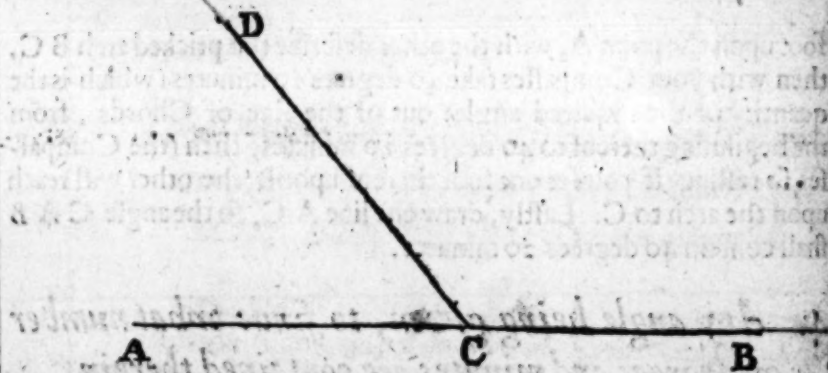
Upon the Ruler there is (besides the severall Scales of equal parts) a Line or Scale of Chords, which is numbered by 10, 20, 30, &c. to 90, and this line serveth to protract or lay down angles; but in all the practise of Surveying a Protractor is much more convenient, yet for other uses this line may be very serviceable, and when a Protractor is wanting, it may supply that defect: the manner how to use it is thus.

3. *How to lay down upon paper, an angle containing any number of degrees and minutes, by the Line of Chords.*

Draw a line at pleasure, as A B, and from the point A, let it be required to protract an angle of 40 degrees 20 minutes. First, extend your Compasses upon the line of Chords, from the beginning thereof to 60 degrees always, and with this distance, setting one foot

1. *To lay down upon paper an angle of any quantity.*

First, draw a right line at length as A B, then on any part thereof, as on C, place the center of the Protractor, in which point also fix your protracting pin, and turn the Protractor about upon the center, till the Meridian line of the Protractor (noted in the description thereof with E F) lie directly on this line A B, the Semicircle of the Protractor lying upwards (or from you) then close to the edge of the Semicircle, at the division of 50 degrees, mark the point D with your protracting pin, and draw the line C D, so shall the angle D C A, contain 50 degrees.



2. *Any angle being given, to finde the quantity thereof by the Protractor.*

Suppose D C B were an angle given, and that it were required to finde the quantity thereof by the Protractor. First, you must apply the center of the Protractor to the point C, and the Meridian line thereof directly upon the line D C, then shall you finde the line C B to lie directly under 130 degrees of the Protractor, and such is the quantity of the angle D C B required.

CHAP. III.

Of the Plain Table, how to set the parts thereof together, and make it fit for the field.

Then you would make your Table fit for the field, lay the three boards thereof together, and also the ledges at each end thereof in their due place, according as they are marked. Then lay a sheet of white paper over the Table, which must be stretched over all the boards by putting on the Frame, which bindes both the paper to the boards, and the boards one to another. Then

Then screw the Socket on the back side of the Table, and also the Box and Needle in its due place, the Meridian line of the Card (which is in the Box) lying parallel to the Meridian or Diameter of the Table, which diameter is a right line drawn upon the Table from the beginning of the degrees through the center, and so to the end of the degrees. Then put the Socket upon the head of the Staffe, and there screw it. Also, put the sights into the Index, and lay the Index on the Table, so is your Instrument prepared for use as a Plain Table or Theodolite, the difference only being in placing of the Index, for when you use your Instrument as a Plain Table, you may pitch your center in any part of the Table, which you shall think most convenient for the bringing on of the work which you intend: But if you use your Instrument as a Theodolite, then the Index must be turned about upon the Center of the Table, for which purpose there is a piece of wiew which goes through a small hole of brasse fastened to the Index, and so into the center, by which means the Index keeps his constant place, only moving up on the center.

Your Instrument being thus ordered, you may use it either as a Plain Table or a Theodolite, but if you would use it as a Circumferentor, you need only screw the Box and Needle to the Index, and both of them to the head of the Staffe, with a brasse screw-pin fitted for that purpose, so that the Staffe being fixed in any place, the Index and sights may turn about at pleasure without moving of the Staffe, and now is your Instrument a good Circumferentor, nay better then that before described in the second Book.

Also, when you have occasion to measure any Altitude, hang the Labell upon the farther Sight, and thus are you exactly fitted for all occasions.

CHAP. IV.

How to measure the quantity of any angle in the field, by the Plain Table, Theodolite, and Circumferentor: and also to observe an angle of Altitude.



You must understand that when I mention the Plain Table, or perform any work thereby, that I mean the Table when it is covered with a sheet of paper, upon which, all observations of angles that are taken upon the Table in the field do agree exactly in proportion with those of the field itself, but are not denominated by their quantities, but by their symmetry or proportion.

Secondly, When I mention the Theodolite, or work by that In-

Instrument, I do not mean the Theodolite before described in the 2 Chapter of the 2 Book, but I mean the degrees described on the frame of the Table, which supplies the use thereof.

Thirdly, When I mention or make use of the Circumferentor, I mean the Index with the Box and Needle screwed to the Staffe.

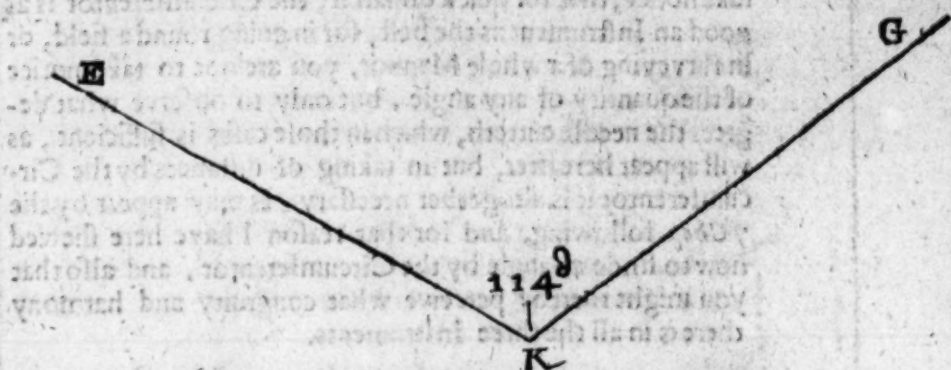
¶ Having thus given you a sufficient description of the severall Instruments and their parts, I come now to the use of them, shewing how any angle in the field may be measured by any of them. And,

1. How to observe an angle in the Field by the Plain Table.

Suppose $E K$ and $K G$ to be two hedges, or two sides of a field, including the angle $E K G$, and that it were required to draw upon your Table, an angle equall thereunto. First, place your Instrument as neer the angular point K , as conveniencie will permit, turning it about till the North end of the Needle hang directly over the Flower-de-luce in the Box, and then screw the Table fast. Then upon your Table, with your protracting pin or Compasse point, assigne any point at pleasure upon the Table, and to that point apply the edge of the Index, turning the Index about upon that point, till through the sights thereof you espie a mark set up at B , or parallel to the line $E K$, and then, with your protracting pin, or Compasse point, or Black-lead, draw a line by the side of the Index to the assigned point upon the Table. Then (the Table remaining immoveable) turn the Index about upon the same point, and direct the sights to a mark set up at G , or parallel thereto, that is, so far distant from G , as your Instrument is placed from K , and then, by the side of the Index, draw another line to the assigned point, so shall you have drawn upon your Table two lines, which shall represent the two hedges $E K$ and $K G$, and those lines shall include an angle equall to the angle $E K G$, and although you know not the quantity of this angle yet you may (by the 1 or 2 Chapters of this Book, finde the quantity thereof if there were any need, for in working by this Instrument, it is sufficient only to give the symmetry or proportion of angles and not their quantities, as in working by the Theodolite or Circumferentor it is. Also, in working by the Plain Table, there needeth no proportion at all, for you shall have upon your Table the true figure of any angle or angles which you observe in the field, in their true positions, without any further trouble.

2. How to finde the quantity of an angle in the field by the Theodolite.

Let it be required to finde the quantity of the angle $E K G$ by the



the Theodolite: place your Instrument at K, laying the Index on the diameter thereof, then turn the whole Instrument about (the Index still resting on the Diameter) till through the sights you espie the mark at E, then screwing the Instrument fast there, turn the Index about upon the center, till through the sights you espie the mark at G, then note what degrees (on the frame of the Table) are cut by the Index, which you will finde to be 114 degrees, and that is the quantity of the angle E K G.

3. How to finde the quantity of any angle in the field, by the Circumferentor.

If it were required to finde the quantity of the former angle E K G, by the Circumferentor, First, place your Instrument (as before) at K, with the Flower-de-luce, in the Card, towards you, then direct your sights to E, and observe what degrees in the Card are cut by the South end of the Needle, which let be 296, then turning the Instrument about the staffe (the Flower-de-luce alwayes towards you) direct the sights to G, noting then also what degrees are cut by the South end of the Needle, which suppose 182, this done (alwayes) subtract the lesser number of degrees out of the greater, as in this Example 182 from 296, and the remainder is 114 degrees, which is the true quantity of the angle E K G.

Again, the Instrument standing at K, and the sights being directed to E, as before, suppose that the South end of the Needle had cut 79 degrees, and then directing the sights to G, the same end of the needle had cut 325 degrees, now, if from 325, you subtract 79, the remainder is 246, but because this remainder 246 is greater then 180, you must therefore subtract 246 the remainder, from 360, and there will remain 114, the true quantity of the inquired angle, and thus you must alwayes do, when the remainder exceedeth 180 degrees.

¶ This adding and subtracting for the finding of angles, may seeme tedious to some, but here the Reader is desired to

take notice, that for quick dispatch, the Circumferentor is as good an Instrument as the best, for in going round a field, or in surveying of a whole Mannor, you are not to take notice of the quantity of any angle, but only to observe what degrees the needle cutteth, which in those cases is sufficient, as will appear hereafter, but in taking of distances by the Circumferentor it is altogether necessary, as may appear by the 7 Chap. following, and for that reason I have here shewed how to finde an angle by the Circumferentor, and also that you might thereby perceive what congruity and harmony there is in all the three Instruments.

4. How to set the Index and Labell Horizontall upon the Staffe.

When you have screwed the Index and sights to the Staffe as a Circumferentor, before you put the Labell upon the brasie pin or wiew, you must hang a line and plummet upon that pin, and then put on the Label, then move the Index up and down till the thread and plummet hang directly upon a line which is gaged from under the pin all along the Sight, and then doth the Instrument stand horizontall or levell, which it must alwayes do when you take an altitude therewith.

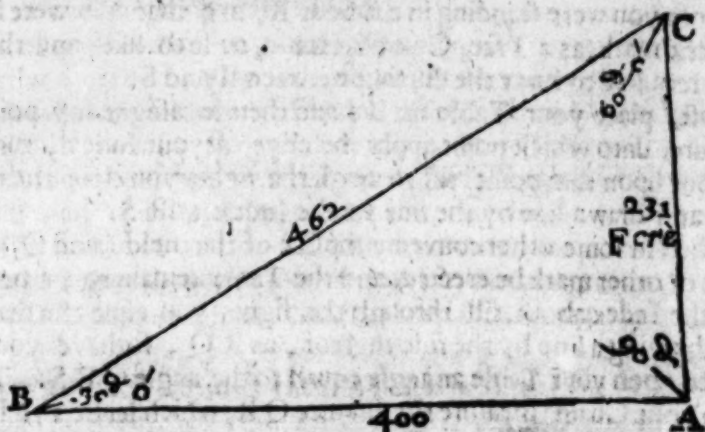
5. How to observe an angle of Altitude.

The Label which is to be hanged on one of the sights of the Circumferentor (as was intimated in the description thereof) and the Tangent line on the edge of the Index, is only for the finding of angles of Altitude, and is therefore only usefull in taking of heights, and in surveying of mountainous and uneven grounds.

The manner how to observe an angle of Altitude by this Label, and the Tangent line on the Index, is thus.

Suppose C A to be a Tree, Tower or Hill, whose height were required. Your Instrument being placed at B, exactly levell, direct the sights thereof towards C A, and there fix it, hanging the Labell on the farthestmost sight, upon a pin for that purpose; then move the Labell too and fro, along the side of the Index, till through the sight at the end of the Label, and by the Pin on which the Label hangeth, you espie the very top of the object to be measured at C, then note what degree of the Tangent line is cut by the Labell, which suppose 30, and that is the quantity of the angle of Altitude, it being equall to the angle C B A.

Thus



Thus by the Rules in this Chapter delivered, may the true quantity of any angle be easily taken, and this is the most convenient use to be first placed, I will now shew how by your severall Instruments yo may take all manner of heights and distances, whether accessible or inaccessible, severall wayes, with divers other necessary conclusions incident thereunto.

CHAP. V.

How to take an inaccessible Distance at two stations by the three forementioned Instruments, and first, by the Plain Table.



You are taught in the last Chapter how to make observation of any angle in the field by the severall Instruments before mentioned, as the Plain Table, Theodolite, and Circumferentor, and also an angle of Altitude by the Index, and the Labell thereunto annexed. I conceive it now convenient to shew how all manner of heights and distances may be readily and exactly measured, severall wayes, whether they be accessible or inaccessible: and first of distances.

¶ You may remember that I formerly intimated, that the measuring of a Height or Distance is only to resolve a Triangle, so that when you make any observation either of Height or Distance, the observation of angles which you make are the angles of some Triangle, and the lines which you measure on the ground, are the sides of the same Triangle, and these are the given parts of the Triangle.

The manner how to take a distance by the Plain Table is thus. Suppose you were standing in a field at R, and that at S were some eminent mark (as a Tree, Church, House, or such like) and that it were required to finde the distance between R and S.

First, place your Table at R, and thereon assigne any point at pleasure, unto which point apply the edge of your Index, turning it about upon that point, till through the sights you espie the mark at S, and draw a line by the side of the Index, as R S.

Then in some other convenient place of the field (as at Q) let a staffe or other mark be erected, and the Table remaining as before, turn the Index about, till through the sights you espie the mark at Q, drawing a line by the side thereof, as R Q, so have you described upon your Table an angle equall to the angle QRS. Then (with your Chain) measure the distance Q R, which let be 176 foot, then take with your Compasses 176 out of any Scale, and set it upon your Table from R to Q, so shall this point Q upon your Table, represent the mark at Q in the field.

This done, set up a staffe at R, and remove your Table to Q, laying the Index upon the line Q R, and holding it fast there, turn the whole Table about till through the sights you espie the mark set up at your former place of standing at R, then screw the Table fast, and lay the Index on the point Q, turning it about, till through the sights you espie your mark at S, then draw a line by the side of the Index, which will cut the line R S (first drawn) in the point S.



By this means shall you have upon your Table a Triangle equall to the Triangle QRS, the correspondent sides and angles thereof being proportionally equall with those in the field: therefore, if with your Compasses you take the length of the side R S, and apply that distance to the same Scale from whence you tooke the side Q R, you shall finde it to contain 400 foot, and that is the distance between R and S. Likewise, if you take with your Compasses the length of the line Q S, and apply it to the same Scale, you shall finde it to contain almost 203, and so many foot is the distance Q S.

In this manner may the distance between any two places be measured, although they be so situated, that by reason of water or other impediments you cannot approach neere unto them. And here note, that when you take your second station, that you take it as large as the ground will permit,

so shall your work be so much the truer, by now much the distance taken is the larger.

CHAP. VI.

How to take an inaccessible distance at two stations by the Theodolite.

IN the former Diagram, let R and Q be two stations, from either of which it is required to finde the distance to S.

First, place your Instrument at R, laying the Index and sights upon the Diameter thereof, turning the whole Instrument about, till through the sights you espie your second station at Q, and there screw it fast, then turn the Index about upon the center, till through the sights you espie the mark at S, noting the degrees cut by the Index, which suppose 45 degrees 10 minutes. Then remove your Instrument to Q, laying the Index on the Diameter thereof, and holding it there, turn the whole Instrument about, till through the sights you espie your mark at S, and fixing the Instrument there, turn the Index about till through the sights you see the mark set up at your former station at R, noting the degrees there cut, which let be 110 degrees 30 minutes. This done, measure the distance of your two stations Q R, which let be 176 foot, To in the Oblique angled Triangle Q S R, you have given, (1) the angle S R Q, 45 degrees 10 minutes, the angle observed at your first station. (2) the angle R Q S, 110 degrees 30 minutes, which was the angle observed at your second station. And (3) you have given the side R Q 176 foot, which is the distance of your two stations: and you are to finde the two other sides R S, and Q S which you may finde by the 7 Case of the 4 Chapter of the 3 Book, in this manner: For as 20. If two angles and one side be given, to find the other two sides.

Having the two angles Q R S, and R Q S given, you have also the third angle R S Q given, 14 degrees 10 minutes, it being the complement of the other two to 180 degrees. (by the 17th of Chap. 3. Lib. 3.) Then to finde the other two sides, the proportion is,

As the sine of the angle R S Q, 14 degrees 10 minutes,

Is to the Logarithm of the side R Q 176 foot,

So is the sine of the angle Q R S 45 degrees 10 minutes,

To the Logarithm of the side Q S, 303 foot *scilicet*.

or 117. For the side R S.

As the sine of the angle Q R S 45 degrees 10 minutes,

Is to the Logarithm of the side Q S, 303 foot,

So is the sine of the angle R Q S 110 deg. 30 min. (or 69 d. 30 m.)

To the Logarithm of the side R S, 400 foot.

Which is the distance required.

¶ I have

C I have been larger upon this particular then I intended (having sufficiently insisted thereon before in the dimension of plain Triangles) but that the Reader may fully understand these necessary conclusions, I have in this example used all the perspicuity I could imagine, so that in the subsequent Chapters I may be the briefer, for this being well understood, he may easily apprehend any of the other at the first view.

CHAP. VII.

How to take an in-accessible distance at two stations by the Circumferentor.

Et it be required to finde the distance from R and Q to S. First, place your Instrument at R, and direct the sights to S, observing what degrees the South end of the Needle cutteth, which let be 315 degrees 30 min. then turning the Instrument about, direct the sights to Q, observing what degrees the needle there cutteth, which let be 270 degrees 30 minutes, therefore from 315 degrees 30 minutes, substract 270 degrees 30 minutes, and there will remain 45 degrees 10 minutes, which is the quantity of the angle S R Q. Then remove the Instrument to Q, and direct the sights to R, the Needle cutting 91 degrees 00 minutes, also, direct the sights to S, the needle cutting 340 degrees 30 minutes, now if you substract 91 degrees 00 minutes, from 340 degrees 30 minutes, the remainder is 249 degrees 30 minutes, which (because it exceedeth 180 degrees) substract from 360 degrees, and there remains 110 degrees 30 min. the true quantity of the angle R Q S.

Having thus obtained the two angles R Q S and S R Q, you must measure the stationary distance Q R 176 foot, so have you given in the Triangle Q R S, (1) the angle R Q S 110 degrees 30 minutes, (2) the angle S R Q, 45 degrees 10 minutes, (3) the angle Q S R, 29 degrees 10 minutes, (the complement of the other two to 180 degrees, and (4) the stationary distance Q R 176 foot, whereby you may finde the other sides Q S and R S, according to the doctrine delivered in the foregoing Chapter.

First station at R, degrees cut

315 30

270 30

The quantity of the angle S R Q

45 10

Second

Second station at Q, degrees cut

deg. min.
540 30
291 00
249 30
360 00
116 30

The quantity of the angle R Q S

The stationer distance 176 foot.

Having these things given, if you resolve the Triangle Q R S, you shall finde the side R S to contain 400 foot, and the side Q S 303 foot *ferè*, as in the last Chapter.

CHAP. VIII.

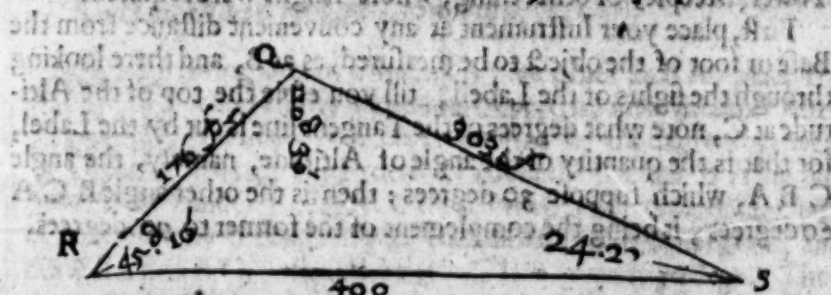
How to protract or lay down a Distance taken, according to the directions of the two last Chapters, upon paper, by help of your Protractor or line of Chords.



When you make any observations in the field, by the Theodolite or Circumferentor, you protract down the quantities of the severall lines and angles observed in the field, in a Book or paper, so that they may be ready at hand when you come to protraction, and this is the usuall way.

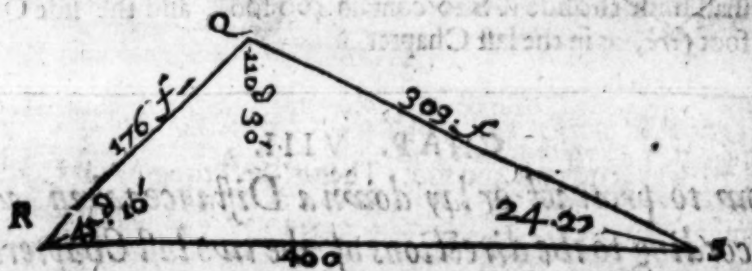
Suppose it were required to draw upon paper or pasteboard the true symmetry or proportion of the distance taken in the last Chapter.

First, upon your paper draw a line as length as R Q, then upon one end thereof, as at R, place the center of your Protractor, and lay the Meridian line E F of the Protractor, directly upon the line



Q R : then, (because the angle Q R S is 45 degrees 10 minutes, therefore, against 45 degrees 10 minutes of your Protractor, make a mark upon your paper with your Protracting pin (as is before taught Chap. 2.) and draw the line R S. This done, from any Scale, take your

your stationarie distance RQ 176 foot, and set it from R to Q . Then upon the point Q (because the angle RQS contains 110 degrees 30 minutes) place the center of the Protractor, and turn it about till the line RQ lie directly under 110 degrees, then (at the point E of the Protractor) make a mark with your protracting pin, and through that point draw the line QS , which will cut the line RS in the point S : then if you measure the length of the lines QS and RS , by the same Scale from whence you took 176 for the line QR , you shall finde the line QS to contain 303, and the line RS to contain 400, exactly agreeing with the numbers found in the last Chapter.



CHAP. IX.

How to take the altitude of any Tower, Tree, Steeple, or the like (being accessible) by the Labell and Tangent line.

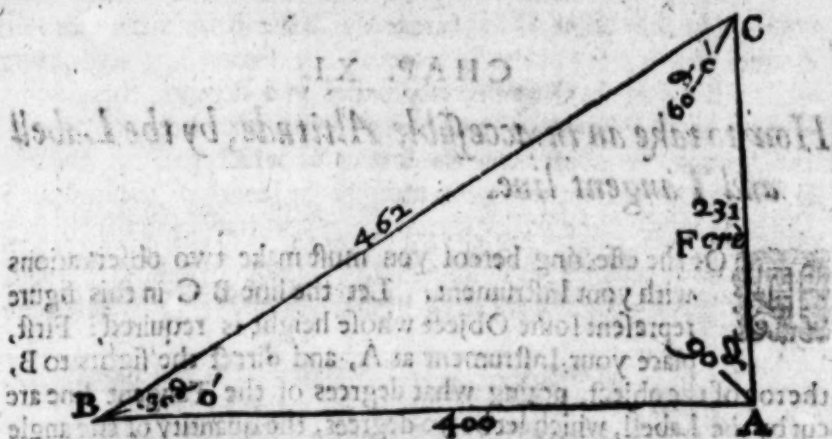


Having in the 3 Section of the 4 Chapter of this Book, shewn how to observe an angle of Altitude by the Labell and Tangent line, we now come to the further use thereof.

Suppose therefore that the line CA were a Tree Tower, Steeple, or other thing, whose height were required.

First, place your Instrument at any convenient distance from the Base or foot of the object to be measured, as at B , and there looking through the sights or the Labell, till you espie the top of the Altitude at C , note what degrees of the Tangent line is cut by the Label, for that is the quantity of the angle of Altitude, namely, the angle CBA , which suppose 30 degrees: then is the other angle BCA 60 degrees, it being the complement of the former to 90 degrees.

Then



Then (with your Chain or otherwise) measure the distance from B (the place of your standing) to A, (the foot of the thing to be measured,) which suppose 400 foot: Then in the Triangle A B C, there is given (1) the angle C B A 30 degrees, (2) the angle B C A, 60 degrees, and (3) the distance B A 400 foot, and it is required to find the side C A, by the 1 Case of right angled plain Triangles:

For,

As the sine of the angle B C A, 60 degrees,
Is to the Logarithm of the side B A 400 foot;
So is the sine of the angle C B A 30 degrees,
To the Logarithm of the side C A.

This proportion being wrought according to the former directions, the side C A will be found to contain almost 231 foot, and that is the height of C A required.

CHAP. X.

How to protract or lay down upon paper, the observation made in the last Chapter.

Having drawn a line upon your paper as B A, place the center of the Protractor upon B, now (because when you made your observation at B, the degrees cut were 30) turn the Protractor about till the line B A lie just under 30 degrees, then (with your protracting pin) make a mark by the edge of your Protractor against 00 degrees, and draw the line B C so shall the angle C B A contain 30 degr. Then (because the measured distance B A was 400 foot,) take 400 from any of your Scales of equal parts, and set that distance from B to A, and from the point A, erect the perpendicular A C, which perpendicular being taken in your Compasses, and measured upon the same Scale from whence the 400 foot was taken, you shall find it to contain almost 231 foot, and so much is the altitude C A as before.

may attain the altitude BC ; for, in the Triangle ABD you have given,

1. The angle BAD , 50 degrees,
2. The angle ABD , 14 degrees,
3. The distance AD 200 foot,

Which (by the former directions) will help you to finde the length of the side DB , either by the Tables in the 3 *Book*, or by the Lines of artificiall Numbers Sines and Tangents on the Index of your Table, as is formerly taught, the proportion being,

As the sine of the angle ABD , 14 degrees,
Is to the Logarithm of the side AD , 200 foot;
So is the sine of the angle BAD , 50 degrees,
To the Logarithm of the side DB .

Which by working according to the former directions, will be found to be 633 foot.

Then must you make a second work in the Triangle BCD , in which you have given,

1. The angle BCD , 90 degrees,
2. The angle DBC 26 degrees,
3. The side DB , 633 foot,

And you are to finde the side BC , the altitude required, wherefore say again,

As the sine of the angle BCD , 90 degrees,
Is to the Logarithm of the side DB 633 foot;
So is the sine of the angle DBC 26 degrees,
To the Logarithm of the Altitude BC .

Which according to the former Doctrine will be found to be 569 foot.

CHAP. XII.

How to Protract the observation taken in the last Chapter.

When you have made your observation as in the last Chapter, and noted down in a Book or otherwise, that the degrees cut at your first station at A were 50, and the degrees cut at the second station at D were 64, and that your stationarie distance AD was 200 foot, you may immediately finde the Altitude BC by protraction, thus.

First, draw a line as AC , in which line let A represent your first station, whereon lay the center of your Protractor, and make the angle BAC to contain 50 degrees (as hath been severall times be-

fore shewn:) and draw the line A B. Then upon the line A C set off the distance of your two stations 200 foot from A to D, then bring your Protractor to D (which represents your second station) and placing the center of your Protractor thereupon, set off an angle of 64 degrees, as B D C, and draw the line D B, then where these two lines A B and D B intersect or meet, which is in the point B, from that point let fall the perpendicular B C, the length whereof being measured upon the same Scale from whence you tooke the distance A D, will give you 569 foot, and that is the altitude of A B, which was required.

CHAP. XIII.

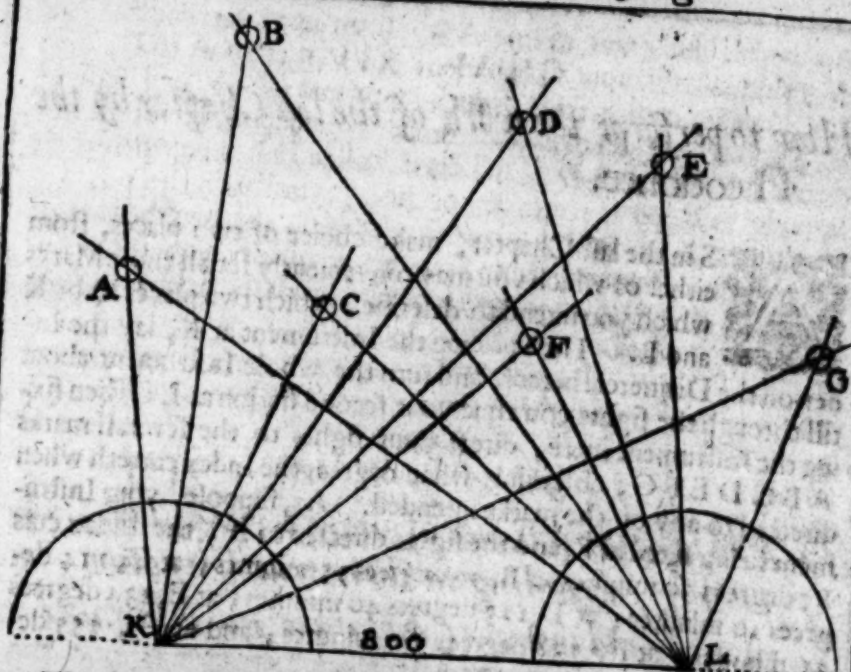
How to take the distance of divers places one from another, according to their true scituation, in plano, and to make (as it were) a Map thereof, by the Plain Table.



His Proposition is of good use to describe in *plano* the most eminent places in a Town or City, and to make (as it were) a Map thereof. Let A B C D E F G, be certain eminent places situate in some Town or City, and let it be required to describe all those places upon paper, by which the distance of any of them one from another, may be readily found.

At some convenient distance from the City, Town, or Field, make choice of two other convenient places as K and L, from either of which you may plainly discern all the marks which you intend to describe in your Map. Then, at one of these places, (as at K) place your Table, and neere one of the sides thereof draw a line parallel to the edge of the Table. In this line assigne any point, as K, for your first station, and laying the Index upon this line, turn the Table about, till through the sights you espie the other place which you intend for your second station, which found, screw the Table fast there.

Then laying the Index to the point K, turn it about, till through the sights you espie your first mark at A, and by the side of the Index draw the line A K. Secondly, turn the Index to the second mark at B, and draw the line B K. Thirdly, direct your sights to C, and draw the line C K. Fourthly, direct your sights to D, and draw the line D K. Fifthly, direct the sights to E, and draw the line E K. Sixthly, direct the sights to F, and draw the line F K. Lastly, direct the sights to G, and draw the line G K, so have you finished your work at your first station.



This done, with your Chain, measure the distance of your two stations K and L, which suppose to contain 800 foot, and removing your Table to L, lay the Index upon the line K L, turning the Table about, till through the sights you see your first station at K, and there screw it fast so that it alter not so long as your work continueth.

Then laying the Index to the point L, direct your sights to the severall marks as before, namely, to A C B F D E G, and from each of those marks draw lines by the side of the Index, as A L, C L, B L, F L, D L, E L, and G L, so is your work finished at your second station also.

Having thus done, first observe where the line K A crosseth the line L A, which is at A, at which point you may draw the figure, or write the name of the thing which it representeth. Secondly, observe where the line K B crosseth the line L B, which is at B, at which point write the name of the place as before. Thirdly, observe where the lines K C and L C intersect, which is at C, at which point also note the place. Fourthly, at the intersection of K D and L D which is at D, write the name of the place as before.


Do thus with all the rest of the places be they never so many, so shall the severall points of intersection A B C D E F G upon your Table, represent the respective places in the Town or City.

Now to know the distance of any of these places one from another, you must take the distance required in your Compasses, and apply it to the same Scale by which the first distance K L was laid down, and it will there shew you the distance required.

21 78 E
04 113 C

CHAP. XIV.

How to perform the work of the last Chapter by the Theodolite.

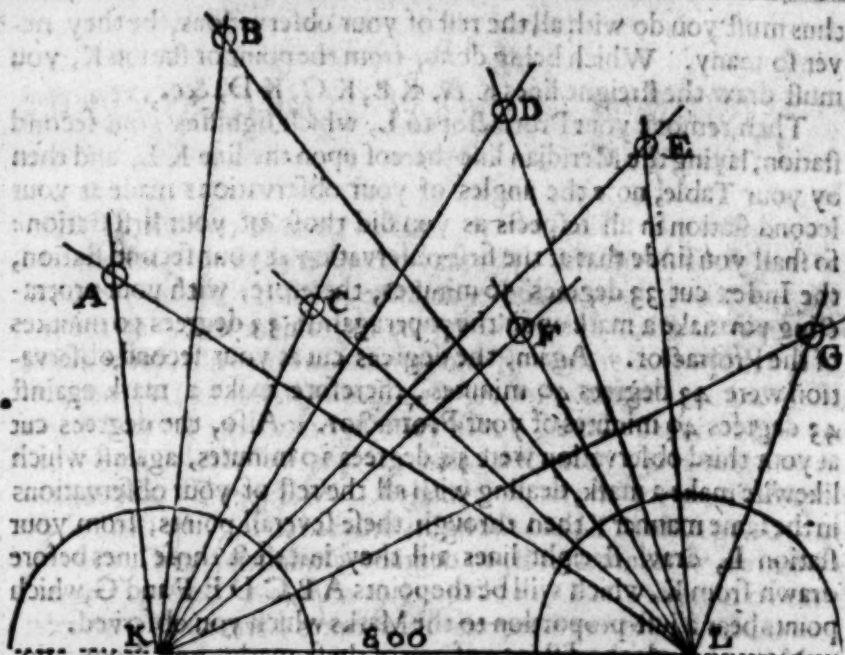
 In the last Chapter, make choice of two places, from either of which you may conveniently see all those Marks which you intend to describe, which two places let be K and L. Then placing the Instrument at K, lay the Index on the Diameter thereof, and turn the whole Instrument about till through the sights you espie your second station at L: then fixing the Instrument there, direct your sights to the severall marks A B C D E F G, observing what degrees the Index cutteth when directed to any of the marks intended. As, suppose, your Instrument being fixed at K, and the sights directed to A, the Index cuts 83 degrees 50 minutes; at B, 97 degrees 55 minutes; at C, 114 degrees 10 minutes; at D, 123 degrees 40 minutes; at E, 134 degrees 35 minutes; at F, 138 degrees 30 minutes; and at G, 155 degrees 20 minutes.

Then removing your Instrument to L, lay the Index on the Diameter thereof, and turn it about till through the sights you espie your former station at K, as is before taught: Then directing the sights to your first mark A, the Index cuts 33 degrees 30 minutes; at C, 43 degrees 40 minutes; at B, 54 degrees 10 minutes; at F, 64 degrees; at D, 73 degrees 20 minutes; at E 87 degrees 15 minutes; and at G, 113 degrees 40 minutes.

These severall observations of the degrees cut by the Index at both stations, ought to be noted in a Book or paper, together with the Stationarie distance, as in this example.

	deg.	min.
First Station		
A	83	50
B	97	55
C	114	10
D	123	40
E	134	35
F	138	30
G	155	20
The Stationarie distance 800 Foot.		
Second Station		
A	33	30
C	43	40
B	54	10
F	64	00
D	73	20
E	87	15
G	113	40

By



By help of this Table of your observations, you may at any time protract the same upon paper, and making a Scale of equal parts answerable to the parts of your station or distance, you may with your Compasses measure the distance of any of these marks or places one from another, or from either of your stations.

CHAP. XV.

How to protract the former Observations upon paper, and to make a Scale to measure any of the Distances.



YOur paper or parchment being provided, draw there-upon a line at length, and therein assigne two points as K and L, representing your two stations, then upon your first station at K, lay the Center of your Protractor, with the Meridian line thereof (which is marked with E F) directly upon the line K L. Then lay the Table of your observations before you, and seeing that at your first observation the Index cut 83 degrees 50 minutes, you must therefore with your protracting pin make a mark against 83 degrees 50 minutes of your Protractor. Again, seeing that at your second observation the Index cut 97 degrees 55 minutes, therefore, with your protracting pin, make a mark upon your paper, against 97 degrees 55 minutes of your Protractor. And thirdly, seeing that at your third observation your Index cut 114 degrees 10 minutes, you must likewise make a mark against 114 degrees 10 minutes, and thus

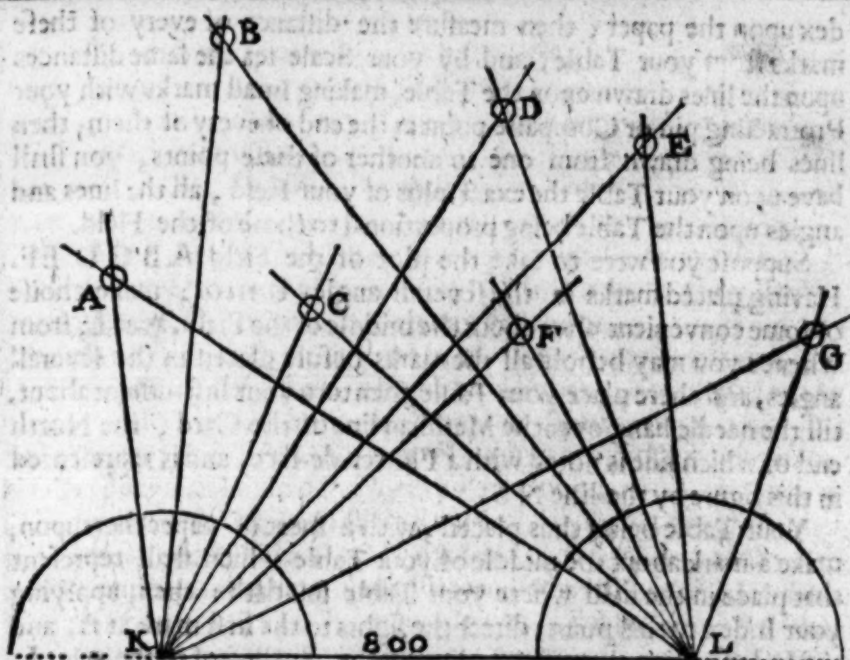
thus must you do with all the rest of your observations, be they never so many. Which being done, from the point or station K, you must draw the streight lines K A, K B, K C, K D, &c.

Then remove your Protractor to L, which signifies your second station, laying the Meridian line thereof upon the line K L, and then by your Table, note the angles of your observations made at your second station in all respects as you did those of your first station: so shall you finde that at the first observation at your second station, the Index cut 33 degrees 50 minutes, therefore, with your protracting pin make a mark upon the paper against 33 degrees 50 minutes of the Protractor. Again, the degrees cut at your second observation were 43 degrees 40 minutes, therefore make a mark against 43 degrees 40 minutes of your Protractor. Also, the degrees cut at your third observation were 54 degrees 10 minutes, against which likewise make a mark, dealing with all the rest of your observations in the same manner: then through these severall points, from your station L, draw streight lines till they intersect those lines before drawn from K, which will be the points A B C D E F and G, which points bear a just proportion to the Marks which you observed.

Now to finde the distance of any of these marks one from another, you must divide a line into such equall parts, so that your stationarie distance K L may contain 800 of them. Your Scale being thus made, take in your Compasses the distance between any two marks or places here described, and apply it to your Scale so shall it exactly shew you the true distance between the two places so taken, in the same parts as the line K L was divided.

In this manner may you with speed and exactnesse attain the true distance and scituation of any Mark or Marks far remote, without approaching neer any of them: and thus in overgrown land, where you can neither go about it, nor measure within it, this Chapter will be of excellent use.

¶ I might here insert divers other Cases concerning the taking of Heights and Distances, as, divers places lying in the same right line to finde their distance, or, part of a Distance or Altitude being given, to finde the whole, with infinite other of that nature, but seeing that these are but parts or branches of what is here delivered, & are rather Problems of curiosity then use, I will therefore passe them over, and the rather, because these being rightly understood, the performance of any other will be very easie. But remember alwayes in taking of inaccessible Heights and Distances, as also in the plotting of un-passeable grounds, that you take your stationarie distance as large as may be. And if at any time you be required to take the altitude of a Castle, Church or Tree, standing on a Hill, you must perform it at two operations, first, by taking the altitude of the Castle and Hill together as one altitude, and secondly, by taking the height of the Hill alone, then by subtracting the height of the Hill from



from the whole height, the remainder shall be the height of the Castle. And here note also, that in the taking of all manner of Altitudes, whether accessible or in-accessible, you must alwayes adde to the height found, the height of your Instrument from the ground.

CHAP. XVI.

How to take the true plot of a field at one station taken within the same field, so that from thence you may see all the angles of the same field, by the Plain Table.

WHen you enter any field to survey, your first work must be to set up some visible mark at each angle thereof, or let one go continually before you to every angle, holding up a white cloth, or the like, to direct you: which being done, make choice of some convenient place about the middle of the field, from whence you may behold all your Marks, and there place your Table covered with a sheet of paper, the needle hanging directly over the Meridian line of the Card (which you must alwayes have regard unto, especially when you are to survey many fields together.) Then make a mark about the middle of your paper, which shall represent that part of the field where your Table standeth, and laying the Index unto this point, direct your sights to the severall angles where you before placed your marks, and draw lines by the side of the In-

dex upon the paper; then measure the distance of every of these marks from your Table, and by your Scale set the same distances upon the lines drawn upon the Table, making small marks with your Protracting pin or Compasse point at the end of every of them, then lines being drawn from one to another of these points, you shall have upon your Table the exact plot of your Field, all the lines and angles upon the Table being proportional to those of the Field.

Suppose you were to take the plot of the Field A B C D E F. Having placed marks in the severall angles thereof, make choise of some convenient place about the middle of the Field, as at L, from whence you may behold all the marks before placed in the severall angles, and there place your Table, then turn your Instrument about, till the needle hang over the Meridian line of the Card, the North end of which line is noted with a Flower-de-luce, and is represented in this figure by the line N S.

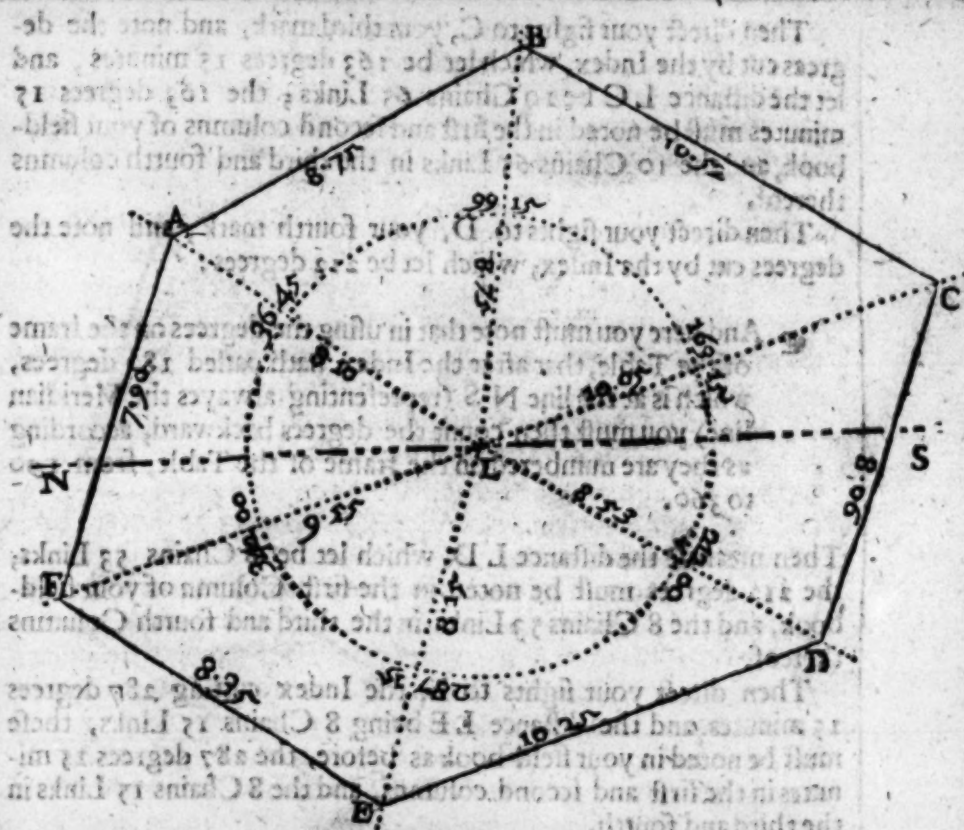
Your Table being thus placed, with a sheet of paper thereupon, make a mark about the middle of your Table which shall represent that place in the field where your Table standeth: then, applying your Index to this point, direct the sights to the first mark at A, and the Index resting there, draw a line by the side thereof to the point L, then with your Chain measure the distance from L, the place where your Table standeth, to A your first mark, which suppose to be 8 Chains 10 Links, then take 8 Chains 10 Links from any Scale, and set that distance upon your Table from L to A, and at A make a mark.

Then directing the sights to B your second mark, draw a line by the side of your Index as before, and measure the distance from your Table at L, to your mark at B, which suppose 8 Chains 75 links, this distance must be taken from your Scale, and set upon your Table from L to B, and at B make another mark.

Then direct the sights to the third mark C, and draw a line by the side of the Index, measuring the distance from L to C, which suppose 10 Chains 65 links, this distance being taken from your Scale and applied to your Table from L to C, shall give you the point C, representing your third mark.

In this manner you must deal with the rest of the marks at D E and F, and more, if the field had consisted of more angles.

Lastly, when you have made observation of all the marks round the Field, and found the points A B C D E and F upon your Table, you must draw lines from one point to another till you conclude where you first began: as draw a line from A to B, from B to C, from C to D, from D to E, from E to F, and from F to A, where you began: then will A B C D E F be the exact figure of your Field, the sides and angles of the said figure bearing an exact proportion to those in the Field, and the line N S, in this and the following figures, always representeth the Meridian line.



CHAP. XVII.

How to take the plot of a field at one station taken in the middle thereof by the Theodolite.

Place marks at the severall angles of the Field as before, and make choice of some convenient place about the middle thereof, as L, from whence you may see all the marks, and there place your Instrument, the Needle hanging directly over the Meridian line in the Card.

This done, direct your sights to the first mark at A, noting what degrees the Index cutteth, which let be 36 degrees 45 minutes, these 36 degrees 45 minutes must be noted down in your Field-book in the first and second Columns thereof. Then measure the distance from L the place of your Instrument, to A your first mark, which let contain 8 Chains 10 Links, these 8 Chains 10 Links must be placed in the third and fourth Column of your Field-book, as hath been directed in the description thereof.

Then direct the sights to B your second mark, and note the degrees cut by the Index, which let be 99 degrees 15 minutes, and the distance L B 8 Chains 75 Links, the 99 degrees 15 minutes must be noted in the first and second Columns of your Field-book, and the 8 Chains 75 Links in the third and fourth Columns.

Then direct your sights to C, your third mark, and note the degrees cut by the Index, which let be 163 degrees 15 minutes, and let the distance LC be 10 Chains 65 Links; the 163 degrees 15 minutes must be noted in the first and second columns of your field-book, and the 10 Chains 65 Links in the third and fourth columns thereof.

Then direct your sights to D, your fourth mark, and note the degrees cut by the Index, which let be 212 degrees:

- ☐ And here you must note that in using the degrees on the frame of the Table, that after the Index hath passed 180 degrees, which is at the line N-S (representing alwayes the Meridian line) you must then count the degrees backward, according as they are numbered on the frame of the Table, from 190 to 360.

Then measure the distance LD, which let be 8 Chains 53 Links, the 212 degrees must be noted in the first Column of your field-book, and the 8 Chains 53 Links in the third and fourth Columns thereof.

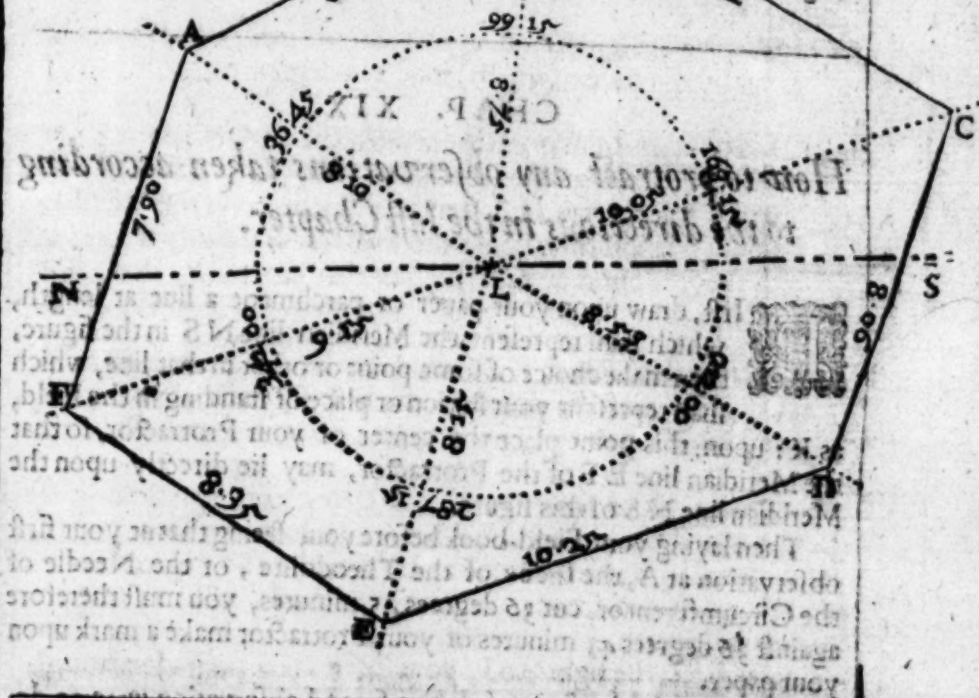
Then direct your sights to E, the Index cutting 287 degrees 15 minutes, and the distance LE being 8 Chains 15 Links, these must be noted in your field-book as before, the 287 degrees 15 minutes in the first and second columns, and the 8 Chains 15 Links in the third and fourth.

Lastly, direct the sights to F, your last mark, the Index cutting 342 degrees, and the distance LF being 9 Chains 55 Links, these must be noted down in your field-book in all respects as the former, *viz.* the 342 degrees in the first column, and the 9 Chains 55 Links in the third and fourth: then will your observations noted in your Field-book stand as in this Table following.

	Degrees	Minutes	Chains	Links
A	36	45	8	10
B	99	15	8	75
C	163	15	10	65
D	212	00	8	53
E	287	15	8	15
F	342	00	9	55

CHAP.

always to cut the same degrees in the Card as the Index of the Theodolite did, and the measured lines L. C. L. D. L. E. and L. F. will be like wise the same. So that the Table of observations in the last Chapter will serve to point out this or the other work, as is taught in the next Chapter.



CHAP. XVIII.

How to take the plot of a Field at one Station taken in the middle thereof by the Circumferentor.

Here is little difference between the work of this and the last Chapter: for, the marks being placed in the severall angles of the field, and the station appointed at L, place there the Instrument, and turning it about, direct the sights to A (the Flower-de-luce of the Card being always towards you) the South end of the Needle cutting 36 degrees 45 minutes, the same which the Index of the Theodolite did in the last Chapter, then measuring the distance from L to A, you will finde it to contain, as before, 8 Chains 10 Links, which you must note down in your Field-book as in the last Chapter.

Then turning the whole Instrument about (as before) direct the sights to B, the South end of the Needle cutting 99 degrees 15 minutes, and the distance L. B. will contain 8 Chains 75 Links, which note down in your Book also.

In this manner must you direct the sights to all the other angles C D E. and F, and you shall finde the South end of the Needle

alwayes to cut the same degrees in the Card as the Index of the Theodolite did, and the measured lines L C, L D, L E, and L F, will be likewise the same, so that the Table of observations in the last Chapter will serve to protract either this or the other work, as is taught in the next Chapter.

CHAP. XIX.

How to protract any observations taken according to the directions in the last Chapter.

First, draw upon your paper or parchment a line at length, which shall represent the Meridian line N S in the figure, then make choice of some point or other in that line, which shall represent your station or place of standing in the Field, as K: upon this point place the center of your Protractor, so that the Meridian line E F of the Protractor, may lie directly upon the Meridian line N S of this figure.

Then laying your Field-book before you, seeing that at your first observation at A, the Index of the Theodolite, or the Needle of the Circumferentor, cut 36 degrees 45 minutes, you must therefore against 36 degrees 45 minutes of your Protractor make a mark upon your paper.

2. Seeing the degrees cut at your second observation were 99 degrees 15 minutes, you must make a mark upon your paper against 99 degrees 15 minutes of your Protractor.

3. The degrees cut at your third observation, were 163 degrees 15 minutes, therefore against 163 degrees 15 minutes make a mark upon your paper.

4. The degrees cut by the Index or Needle at your fourth observation being 212 degrees,

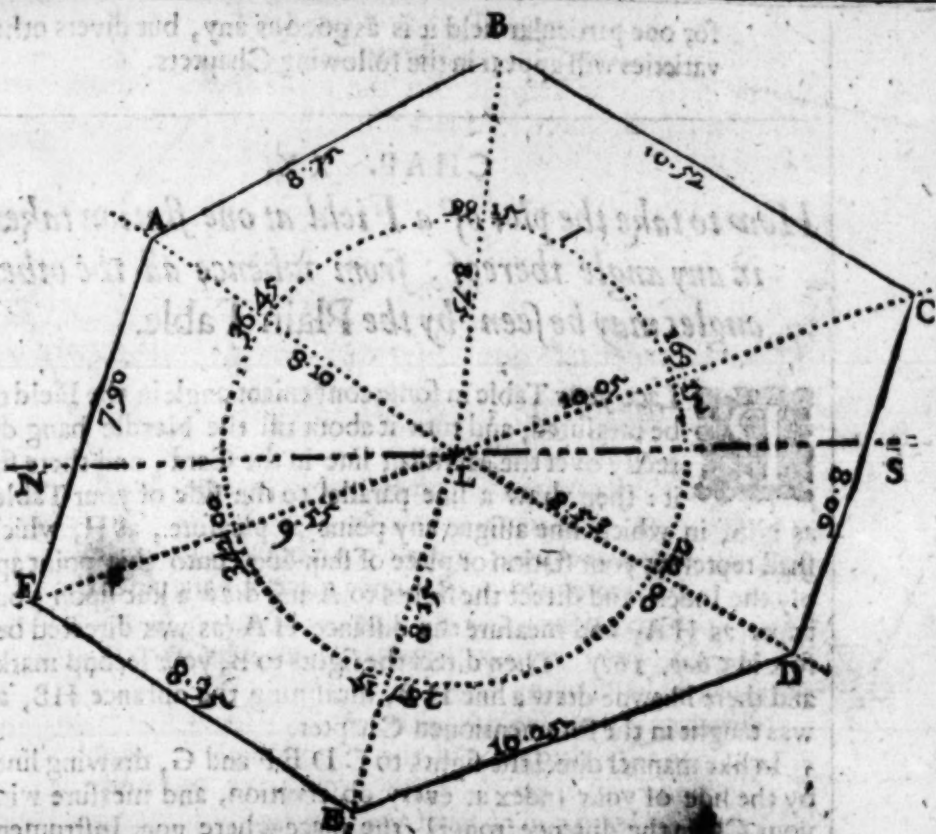
Now because 212 degrees is greater then 180 degrees, you must therefore turn the Semicircle of the Protractor downwards, yet the line E F thereof must lie directly upon the Meridian line N S, as before.

== you must against 212 degrees of the Protractor make a mark upon your paper.

5. Seeing the degrees cut at your fifth observation were 287 degrees 15 minutes, therefore make a mark against 287 degrees 15 minutes of the Protractor.

Lastly, the degrees cut at your last observation, were 342, therefore against 342 degrees of your Protractor make a mark with your Protracting pin, as before.

Having thus protracted all the degrees of your severall observations, take away your Protractor, and laying a ruler to the point L, draw



draw obscure lines from *L* through those points, which lines will be *LA*, *LB*, *LC*, *LD*, *LE*, and *LF*.

This done, you must observe by your Field-book the length of every line.

As the line *LA* at your first observation was 8 Chains 10 Links, therefore, 8 Chains 10 Links being taken from your Scale, and set upon your paper from *L* to *A*, it shall give you the point *A* upon your paper.

2. The length of your second line being 8 Chains 75 Links, you must take 8 Chains 75 Links from your Scale, and set it upon your paper from *L* to *B*.

3. The line *LC* being 10 Chains 05 Links, you must therefore take 10 Chains 05 Links from your Scale, and set it upon your paper from *L* to *C*.

And thus must you deal with all the rest of the lines, as *LD*, *LE*, and *LF*.

Lastly, draw the lines *AB*, *BC*, *CD*, *DE*, *EF*, and *FA*, so shall you have the exact figure of the Field upon your paper.

In these four last Chapters you are taught how to take the plot of any field at one station taken in the midst thereof, both by the Plain Table, Theodolite, and Circumferentor, and also how to protract the same. This way of plotting of a field is seldome, or never, used in surveying of divers parcels, but for

for one particular field it is as good as any, but divers other varieties will appear in the following Chapters.

CHAP. XX.

How to take the plot of a Field at one station taken in any angle thereof, from whence all the other angles may be seen, by the Plain Table.

Place your Table in some convenient angle in the Field to be measured, and turn it about till the Needle hang directly over the Meridian line in the Card, and there fix it: then draw a line parallel to the side of your Table, as N S, in which line assigne any point at pleasure, as H, which shall represent your station or place of standing, unto this point apply the Index, and direct the sights to A and draw a line upon your paper as H A, and measure the distance H A (as was directed before in Chap. 16.) Then direct the sights to B, your second mark, and there likewise draw a line H B, measuring the distance H B, as was taught in the forementioned Chapter.

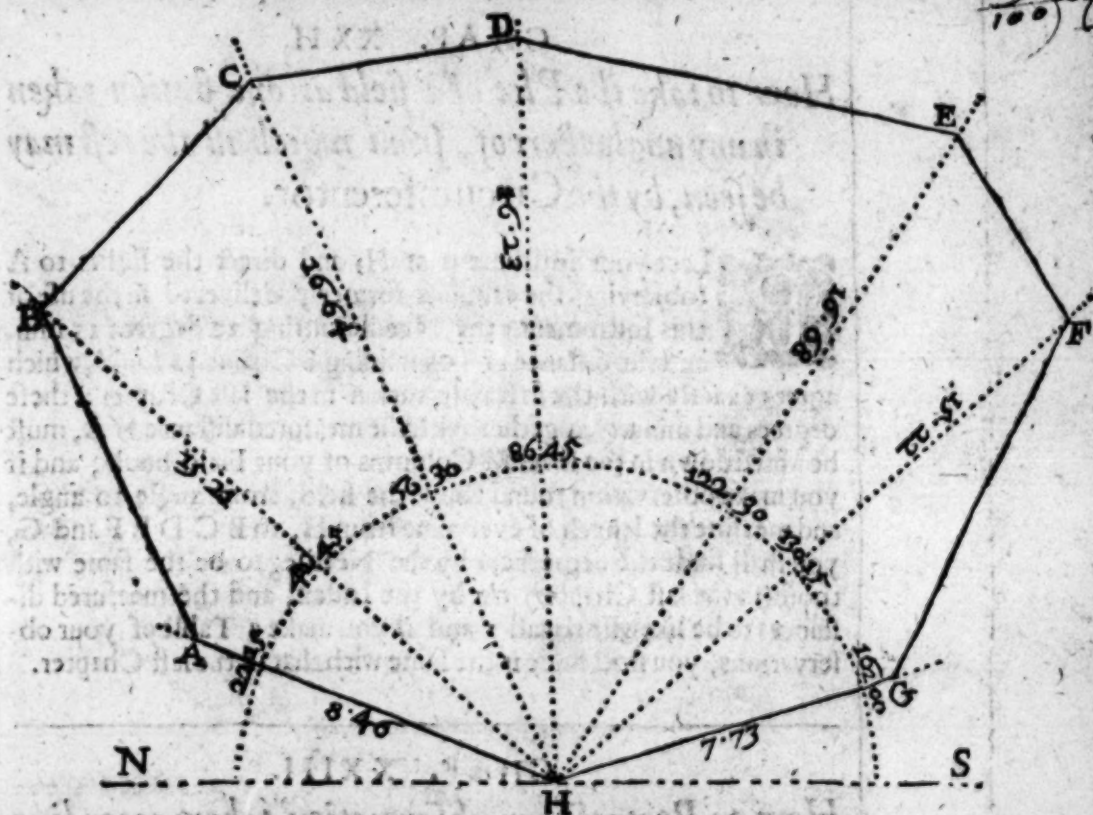
In like manner direct the sights to C D E F and G, drawing lines by the side of your Index at every observation, and measure with your Chain the distance from H (the place where your Instrument standeth) to the severall angles of the Field, as A, B, C, D, E, F, and G; which distances being taken in your Compasses, from any scale, and set upon your Table from H upon the severall lines H A, H B, H C, H D, H E, H F, and H G, so shall you have upon your Table the points A, B, C, D, E, F, and G, by which marks draw the lines H A, A B, B C, C D, D E, E F, F G, and G H, which lines will include the exact figure of the Field upon your Table.

CHAP. XXI.

How to take the plot of a Field at one station taken in any angle thereof by the Theodolite.

In the same figure following, having placed your Instrument at H, as is taught in the foregoing Chapter, direct the sights to A, your first mark, noting the degrees cut by the Index, which suppose 32 degrees 15 minutes, these degrees and minutes must be noted in the first and second columns of your Field-book (as hath been before sufficiently taught.) Then with your Chain, measure the distance from your station at H to the angle A, which let be 3 Chains 46 Links, which you must place in the third and fourth columns of your Field-book, according to the former directions.

2. Direct



2. Direct your sights to B, noting the degrees there cut, which suppose 42 degrees, 45 minutes, these degrees and minutes place in the first and second Columns of your Field-book, and measure the distance H B, 15 Chains 21 Links, and note them down in the third and fourth Columns thereof.

3. Direct your sights to C, the degrees cut being 66 degrees 30 minutes, and the distance H C 16 Chains 64 Links, note these also in your Field-book as before.

And in this manner must you deal with the other marks D, E, F, and G, so having noted them all in your Field-book they will stand as followeth.

	Degrees	Minutes	Chains	Links
A	42	45	15	21
B	66	30	16	64
C	86	45	16	43
D	122	30	16	68
E	130	15	15	22
F	161	00	7	73
G				

CHAP. XXII.

How to take the Plot of a field at one station taken in any angle thereof, from which all the rest may be seen, by the Circumferentor.

PLace your Instrument at H, and direct the sights to A (observing the cautions formerly delivered in the use of this Instrument) the Needle cutting 22 degrees 15 min. and the distance HA containing 8 Chains 46 Links, which agrees exactly with the first observation in the last Chapter: these degrees and minutes, together with the measured distance H A, must be noted down in the severall Columns of your Field-book, and if you make observation round about the field, from angle to angle, and measure the length of every line from H, to B C D E F and G, you shall finde the degrees cut by the Needle, to be the same with those (in the last Chapter) cut by the Index, and the measured distances to be likewise equall: and if you make a Table of your observations, you shall finde it the same with that in the last Chapter.

CHAP. XXIII.

How to Protract any observation taken according to the Doctrine of the two last Chapters.

First, draw the meridian line N S, and make choice of a point therein representing your Stationary angle, as at H, to which point apply the center of your Protractor, the Semicircle upwards. Then laying your Field-book before you, you may perceive that at your first observation (which was at A) the Index of the Theodolite, or the Needle of the Circumferentor cut 22 degrees 15 minutes, therefore make a mark against 22 degrees 15 minutes, and draw the line H A.

1. The degrees cut at your second observation at B, being 42 degrees 45 minutes, make a mark likewise against 42 degrees 45 min. of your Protractor, and draw the line H B.

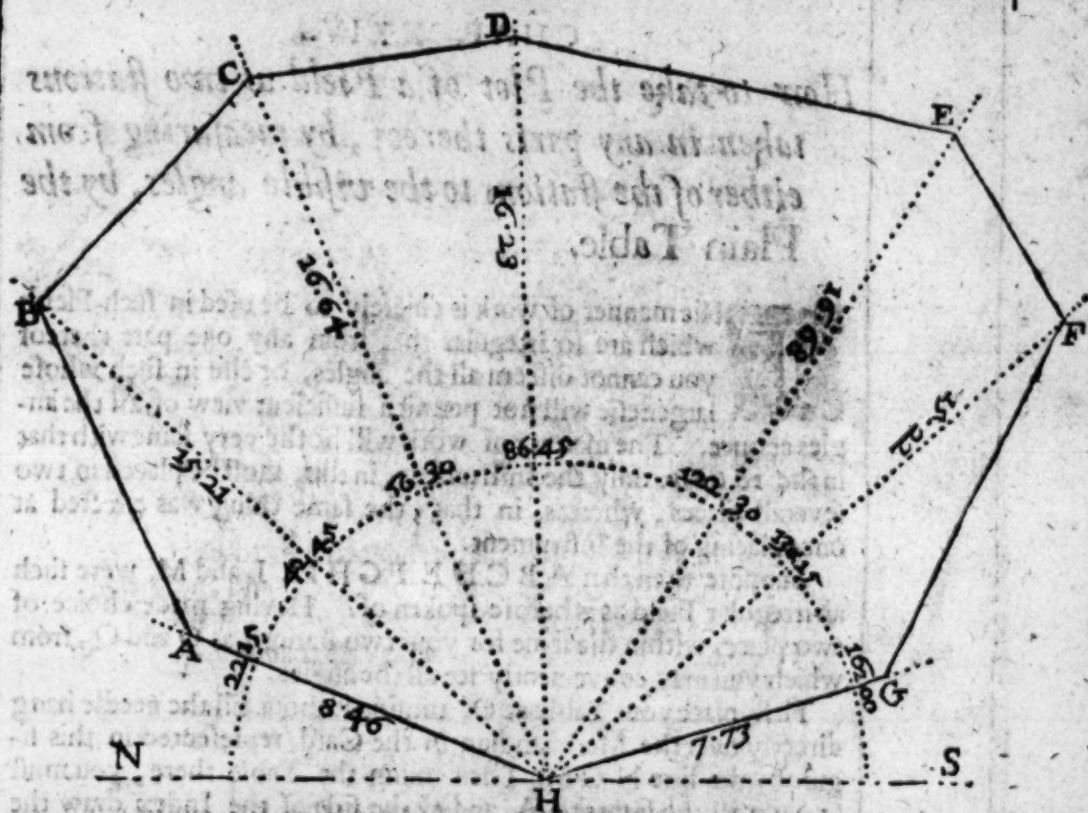
2. The degrees cut at your third observation being 66 deg. 30 min. make a mark against 66 degrees 30 minutes, and draw the line H C.

And in this manner must you proceed with the rest of your observations, D, E, F, and G.

Having thus protracted your angular observations, proceed now to your lineall, namely, to the length of your lines, noted in the third and fourth Columns of your Field-book.

1. Seeing that the length of your first line H A was 8 Chains 46 Links, you must take 8 Chains 46 Links from your Scale, and apply it to your paper from H unto A.

3. The



2. The length of your second line HB, being 35 Chains 21 Links, take 35 Chains 21 Links from your Scale, and apply that distance to your paper from H unto B.

3. The distance of your third mark HC being 16 Chains 64 Links, take that distance from your Scale, and apply it to your paper from the point H unto C.

In all respects as before, you must proceed with the measuring of all the other lines about the field, were they never so many.

Lastly, if from these points A B C D E F G and H, you draw the lines AB, BC, CD, DE, EF, FG, and GH, you shall have upon your paper the exact figure of your field.

¶ And herein you may receive abundant satisfaction, to see your severall Instrumentall operations, and your Geometrical protraction so exactly to agree: and if at any time you make severall observations of any one piece of ground, according to the directions of the foregoing Chapters, or the like, if you finde them not exactly to agree, you may be sure you have failed in one or other of your observations, and therefore, before you proceed further, it is best to reform your first error.

CHAP. XXIV.

How to take the Plot of a Field at two stations taken in any parts thereof, by measuring from either of the stations to the visible angles, by the Plain Table.

THis manner of work is chiefly to be used in such Fields which are so irregular that from any one part thereof you cannot discern all the angles, or else in such whose largeness will not permit a sufficient view of all the angles at once. The manner of work will be the very same with that in the 16 Chap. only the Instrument, in this, must be placed in two severall places, whereas, in that, the same thing was effected at once placing of the Instrument.

Suppose then that A B C D E F G H I K L and M, were such an irregular Field as is before spoken of. Having made choice of two places within the same for your two stations, as O and Q, from which you may conveniently see all the angles.

First, place your Table at O, turning it about till the needle hang directly over the Meridian line in the Card, represented in this figure by the line N O S. Then fixing the Table there, you must (1.) direct the sights to A, and by the side of the Index draw the line A O, containing 7 Chains 46 Links.

(2.) direct the sights to B, and draw the line B O, containing 7 Chains 18 Links.

(3.) direct the sights to C, and draw the line O C, containing 7 Chains 11 Links.

(4.) direct the sights to D, and draw the line O D, containing 6 Chains 33 Links.

(5.) direct the sights to E, and draw the line O E, containing 5 Chains 57 Links.

(6.) direct the sights to K, and draw the line O K, containing 7 Chains 83 Links.

(7.) direct the sights to L, and draw the line O L, containing 9 Chains 95 Links.

(8.) direct the sights to M, and draw the line O M, containing 5 Chains 8 Links.

Having thus made observation of these angles which are all that can conveniently be seen from your first station at O, and drawn the severall lines O A, O B, O C, O D, O E, O K, O L, and O M, and upon them set the severall lengths as you found them by measuring, as from O to A, 7 Chains 46 Links, from O to B, 7 Chains 18 Links, &c. you must then lay the Index again to the point O, and direct the sights to your second station at Q, drawing the line O Q, then measure the distance from O to Q, which let contain 8 Chains 89 Links.

Then

And here note, that in this Example I make observation of the angles E and K at both stations, but there was no deed thereof, only this satisfaction will accrue thereby, for when you have measured your stationarie distance O Q, and removed your Instrument to Q, and there fixed it, when you direct the sights to E or K, and measure the distance Q E or Q K, and set it off from Q, you shall finde the points E and K to fall directly upon the same points E and K formerly drawn, if there be no error in your work.

And in this manner may you make three four or five stations for one field if need so require, remembreing alwayes, that at every station the Needle hang directly over the Meridian line, or the same degree of the Card at every station.

CHAP. XXV.

How to take the true Plot of a Field at two stations taken in any parts thereof, from whence the angles may be seen by the Theodolite.



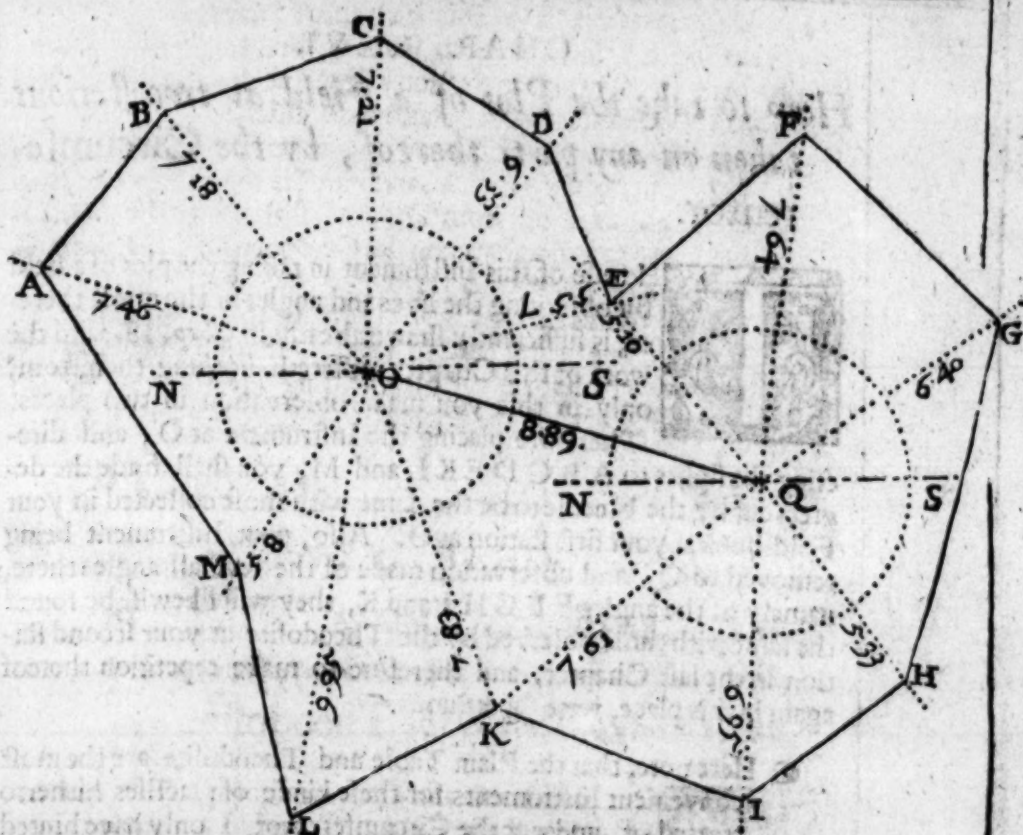
Our stations O and Q being chosen, place your Instrument in the Field at O, and turn it about till the Needle hang over the Meridian line, and there fixing it, direct the sights to A, the Index cutting 19 degrees 10 minutes, and the line O A containing 7 Chains 46 Links, the 19 degrees 10 minutes must be placed in the first and second columns of your Field-book, and the 7 Chains 46 Links in the third and fourth columns thereof.

Then direct the sights to B, the Index cutting 53 degrees 30 minutes, and the line O B containing 7 Chains 18 Links, which note down in your Field-book as before.

In this manner proceed with the rest of the lines and angles, namely, so many as you intend to observe at your first station, *viz.* A, B, C, D, E, K, L, and M: which done, direct the sights to your second station at Q, the Index cutting 18 degrees 15 minutes, which note down in your Field-book by it selfe: Also measure the stationarie distance O Q, 8 Chains 89 Links, as before, this also must be noted in your Field-book.

Having thus finished one part of the Field, remove your Instrument to Q, and laying the Index upon 18 degrees 15 minutes, (which is the inclination or difference of Meridians between your two stations) turn it about till through the sights you espie your first station at O, then will the Needle hang over the Meridian line, and the Instrument will be truly situate.

Then direct the sights to E, the Index cutting 52 degrees 15 minutes, and the line Q E containing 5 Chains 10 Links, which must



be noted in your Field-book in all respects as formerly. In this manner make observation of all the other lines and angles, as E F G H I and K, which being collected into your Field-book will stand as followeth.

	Deg.	Min.	Chai.	Links
A	19	10	7	46
B	53	30	7	18
C	95	15	7	21
D	132	00	6	33
E	166	30	5	57
K	251	30	7	83
L	282	00	9	95
M	304	30	8	05

The first station at O.

The stationarie distance O Q is 8 Chains 89 Links, and the angle O Q N 18 degrees 15 minutes, the inclination or difference of Meridians.

E	52	15	5	101
F	99	30	7	64
G	148	30	6	40
H	232	30	5	33
I	275	00	6	95
K	321	30	7	61

The second station at Q.

CHAP. XXVI.

How to take the Plot of a Field at two stations taken in any parts thereof, by the Circumferentor.



He use of this Instrument in taking the plot of a field by observing the lines and angles in the midst thereof, is sufficiently shewn already in Chap. 18. and the work of this Chapter differeth nothing therefrom, only in this you make observation in two places. Therefore placing the Instrument at O, and directing the sights to A B C D E K L and M, you shall finde the degrees cut by the Needle to be the same with those collected in your Field-book at your first station at O. Also, your Instrument being removed to Q, and observation made of the severall angles there, namely of the angles E F G H I and K, they will likewise be found the same with those observed by the Theodolite at your second station in the last Chapter, and therefore to make repetition thereof again in this place, were superfluous.

¶ Here note, that the Plain Table and Theodolite are the most convenient Instruments for these kinde of practises hitherto treated of, and not the Circumferentor, I only have hinted the use thereof, that the agreement of the severall Instruments might be taken notice of, the Circumferentor serving chiefly for large Champion plains and Wood-lands, as will appear hereafter.

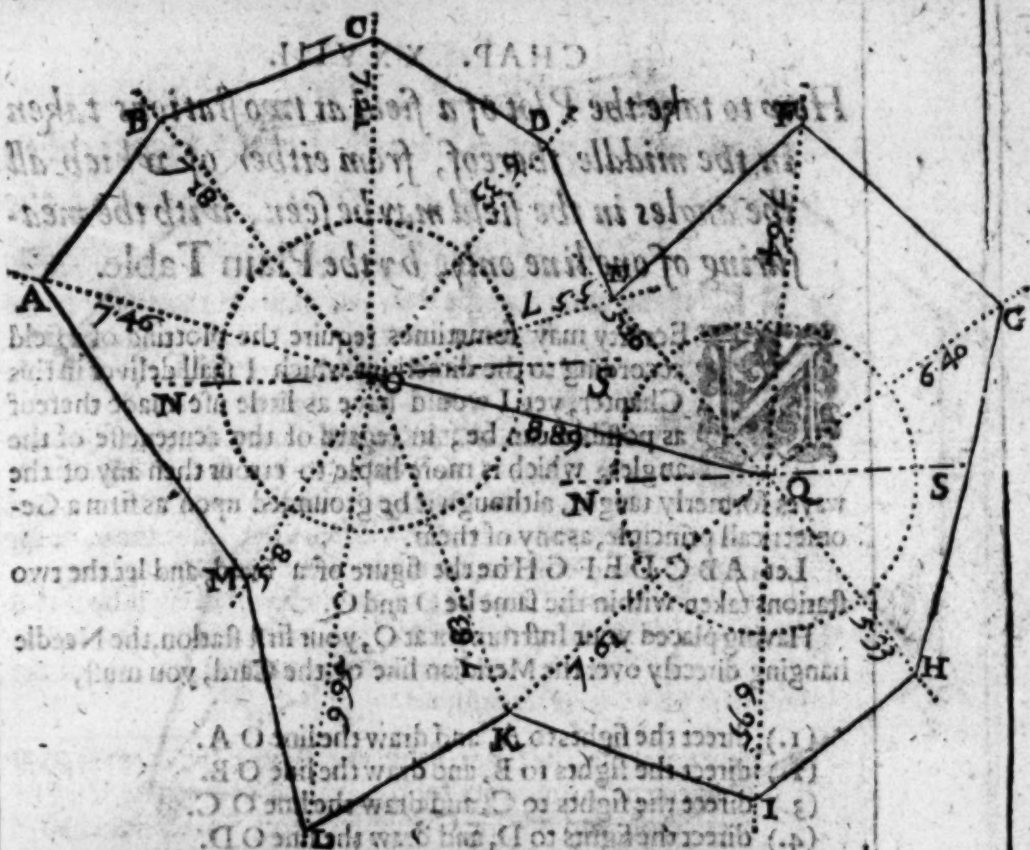
CHAP. XXVII.

How to protract any observations taken according to the directions of the two last Chapters.

Draw upon your paper the Meridian line N O S, the point O representing your first station: upon this point O place the center of your Protractor, laying the line E F thereof, directly upon the Meridian line N S. Then laying your Field-book before you, observe the degrees there noted, namely,

- (1.) at A, 19 degrees 10 minutes, the line O A containing 7 Chains 46 Links.
- (2.) at B, 53 degrees 30 minutes, the line O B containing 7 Chains 18 Links.
- (3.) at C, 95 degrees 15 minutes, the line O C containing 7 Chains 21 Links.

And



And so of the rest, against which degrees and minutes make marks by the edge of your Protractor, and draw lines from O through those marks, as O A, O B, O C, O D, O E, O K, O L, O M, and upon those lines set off the lengths from O, as you finde them collected in your Field-book.

Having thus protracted the observations of your first Station (before you move your Protractor) make a mark against 18 degrees 15 minutes which is the inclination or difference of Meridians, and draw the line O Q, setting off 8 Chains 89 Links the length thereof from O to Q. Then upon the point Q, place the center of the Protractor as before, moving it up and down till the line O Q lies just under 18 degrees 15 minutes, and holding it there, lay your Field-book before you, and prick down by the side thereof the severall degrees and minutes as by your Instrument you observed them, together with the lengths of the lines as they were measured, drawing lines through those points also, as the lines Q B, Q F, Q G, Q H, Q I, and Q K.

Lastly, draw the lines A B, B C, C D, D E, E F, &c. so shall you have upon your paper the exact plot of your field, in which (if there be no error in your work) the line M A being drawn will close exactly with the line B A in the point A.

CHAP. XXVIII.

How to take the Plot of a field at two stations taken in the middle thereof, from either of which all the angles in the field may be seen, with the measuring of one line only, by the Plain Table.

Necessity may sometimes require the plotting of a field according to the directions which I shall deliver in this Chapter, yet I would have as little use made thereof as possible can be, in regard of the acutenesse of the angles, which is more liable to error then any of the wayes formerly taught, although it be grounded upon as firm a Geometricall principle, as any of them.

Let $ABCDEF GH$ be the figure of a Field, and let the two stations taken within the same be O and Q .

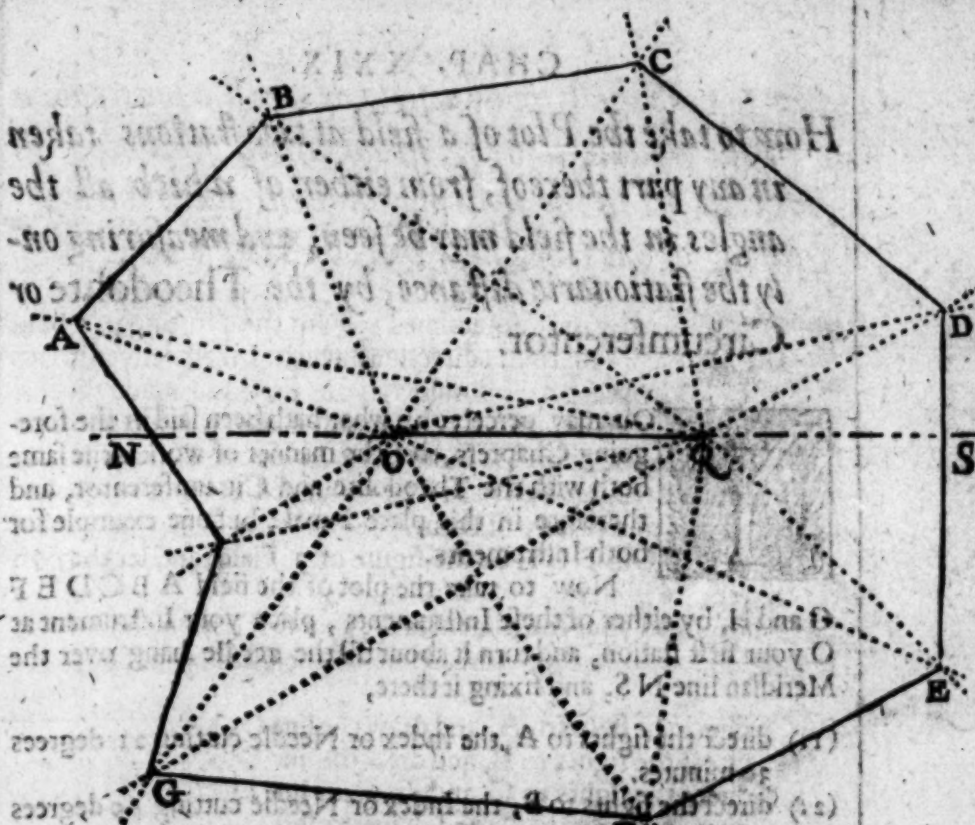
Having placed your Instrument at O , your first station, the Needle hanging directly over the Meridian line of the Card, you must,

- (1.) direct the sights to A , and draw the line OA .
- (2.) direct the sights to B , and draw the line OB .
- (3.) direct the sights to C , and draw the line OC .
- (4.) direct the sights to D , and draw the line OD .
- (5.) direct the sights to E , and draw the line OE .
- (6.) direct the sights to F , and draw the line OF .
- (7.) direct the sights to G , and draw the line OG .
- (8.) direct the sights to H , and draw the line OH .

This done, direct the sights to your second station at Q , and draw the line OQ upon your Table: then (with your Chain) measure out your stationarie distance OQ , which is 7 Chains, and removing your Instrument to Q (the needle hanging over the Meridian line of the Card as before) make observation as you did at O , As,

- (1.) direct the sights to A , and draw the line QA .
- (2.) direct the sights to B , and draw the line QB .
- (3.) direct the sights to C , and draw the line QC .
- (4.) direct the sights to D , and draw the line QD .
- (5.) direct the sights to E , and draw the line QE .
- (6.) direct the sights to F , and draw the line QF .
- (7.) direct the sights to G , and draw the line QG .
- (8.) direct the sights to H , and draw the line QH .

Now



Now you may plainly perceive by the figure, when the corresponding lines at each station intersect or cross each other, as,

- (1.) the lines O A and Q A intersect each other at A.
- (2.) the lines O B and Q B intersect each other at B.
- (3.) the lines O C and Q C intersect each other at C.
- (4.) the lines O D and Q D intersect each other at D.
- (5.) the lines O E and Q E intersect each other at E.
- (6.) the lines O F and Q F intersect each other at F.
- (7.) the lines O G and Q G intersect each other at G.
- (8.) the lines O H and Q H intersect each other at H.

Therefore, if from one to another of these points successively you draw lines, you shall have upon your paper the exact symmetry or proportion of your field, as namely, the lines A B, B C, C D, D E, &c.

In this kind of plotting you cannot but perceive a wonderful quick dispatch, you being to measure nothing but the distance between your stations, nor by reason of the accuracy of the angles (without exact and curious drawing of your lines, and observing the precise points of intersection) you may run into gross absurdities and mistakes.

CHAP. XXIX.

How to take the Plot of a field at two stations taken in any part thereof, from either of which all the angles in the field may be seen, and measuring only the stationarie distance, by the Theodolite or Circumferentor.



You may perceive by what hath been said in the foregoing Chapters, that the manner of work is the same both with the Theodolite and Circumferentor, and therefore in this place I make but one example for both Instruments.

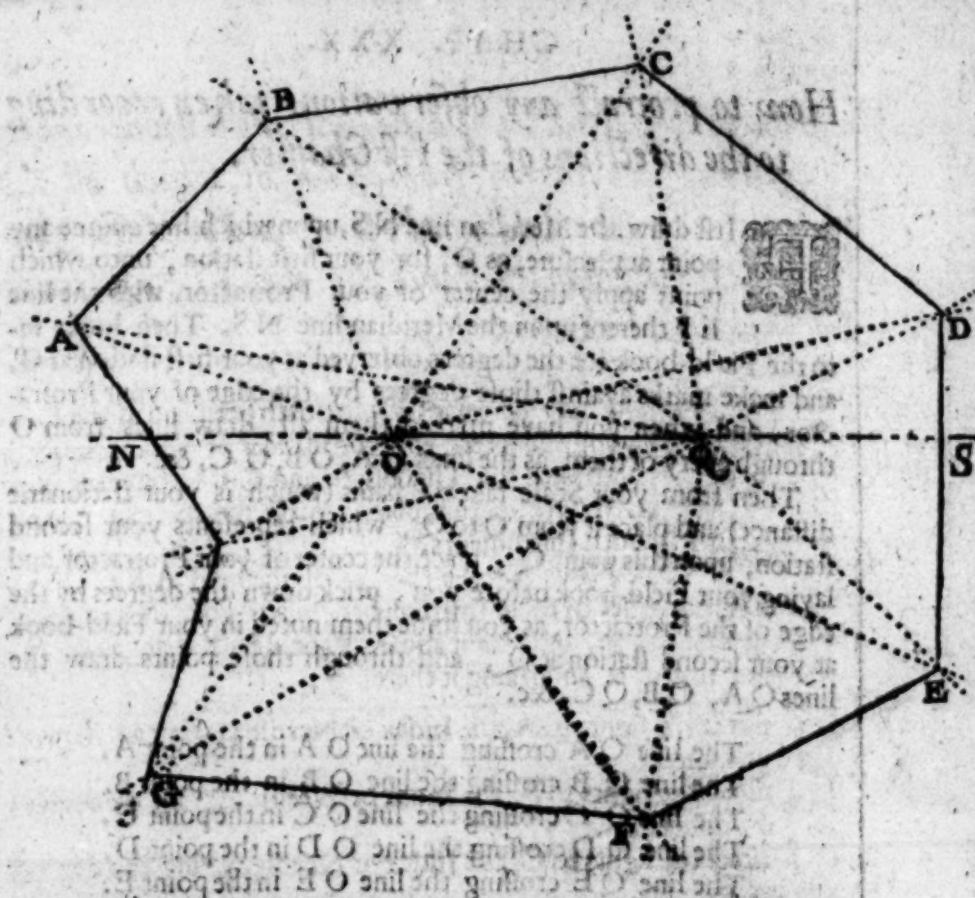
Now to take the plot of the field A B C D E F G and H, by either of these Instruments, place your Instrument at O your first station, and turn it about till the needle hang over the Meridian line N S, and fixing it there,

- (1.) direct the sights to A, the Index or Needle cutting 21 degrees 30 minutes.
- (2.) direct the sights to B, the Index or Needle cutting 69 degrees 15 minutes.
- (3.) direct the sights to C, the Index or Needle cutting 124 degrees 45 minutes.
- (4.) direct the sights to D, the Index or Needle cutting 168 degrees 10 minutes.
- (5.) direct the sights to E, the Index or Needle cutting 202 degrees 30 minutes.
- (6.) direct the sights to F, the Index or Needle cutting 237 degrees 30 minutes.
- (7.) direct the sights to G, the Index or Needle cutting 307 degrees 00 minutes.
- (8.) direct the sights to H, the Index or Needle cutting 328 degrees 30 minutes.

This done, measure your stationarie distance O Q, which suppose to contain 7 Chains, and remove your Instrument to Q, turning it about till the Needle hang directly over the Meridian line as before, and then fix it again,

- (1.) direct the sights to A, the Index or Needle cutting 12 degrees 00 minutes.
- (2.) direct the sights to B, the Index or Needle cutting 33 degrees 30 minutes.
- (3.) direct the sights to C, the Index or Needle cutting 79 degrees 45 minutes.

(4.) di.



- (4.) direct the sights to D, the Index or Needle cutting 53 degrees 15 minutes.
- (5.) direct the sights to E, the Index or Needle cutting 124 degrees 30 minutes.
- (6.) direct the sights to F, the Index or Needle cutting 170 degrees 30 minutes.
- (7.) direct the sights to G, the Index or Needle cutting 329 degrees 00 minutes.
- (8.) direct the sights to H, the Index or Needle cutting 347 degrees 30 minutes.

Having thus made observation of all the angles round about the field at both stations and noted the degrees cut by the Index of the Theodolite or the Needle of the Circumferentor, and noted them down in your Field-book, together with the distance between your two stations, you may proceed to protract your work as is taught in the next Chapter.

CHAP. XXX.

How to protract any observations taken according to the directions of the last Chapter.

Irst draw the Meridian line N S, upon which line assigne any point at pleasure, as O, for your first station, unto which point apply the center of your Protractor, with the line E F thereof upon the Meridian-line N S. Then looke into the Field-book for the degrees observed at your first station at O, and make marks against those degrees by the edge of your Protractor, and when you have marked them all, draw lines from O through every of them, as the lines O A, O B, O C, &c.

Then from your Scale take 7 Chains (which is your stationarie distance) and place it from O to Q, which represents your second station, upon this point Q, place the center of your Protractor, and laying your Field-book before you, prick down the degrees by the edge of the Protractor, as you finde them noted in your Field-book at your second station at Q, and through those points draw the lines Q A, Q B, Q C, &c.

The line Q A crossing the line O A in the point A.

The line Q B crossing the line O B in the point B.

The line Q C crossing the line O C in the point C.

The line Q D crossing the line O D in the point D.

The line Q E crossing the line O E in the point E.

The line Q F crossing the line O F in the point F.

The line Q G crossing the line O G in the point G.

The line Q H crossing the line O H in the point H.

Therefore if you draw the lines A B, B C, C D, D E, E F, F G, G H, and H A, it shall be the exact plot or figure of the field required.

I might now proceed to shew you the manner of taking the plot of any field without approaching nigh the same; but in regard the performance thereof differeth nothing at all from that which is already taught in the 13, 14, and 15 Chapters of the fourth Book, I shall therefore in this place passe it over as superfluous.

The whole or the Needle of the Compass, and hold it down in your Field-book, together with the distance between your two stations, you may proceed to plot your field as taught in the next Chapter.

CHAP.

CHAP.

Work on other **Complex** permutation group, what if you change to take
 Suppose the following input A B C D H I G to be a list

A. I have seen your statement from A, and I am a little
 what good and what your statement at the second place;
 about the fact upon the A. I am a little
 about the fact upon the A. I am a little
 about the fact upon the A. I am a little

10

the back of your hand for up to 10 minutes.

...and, as a result, the ...

CHAP. XXXI.

CHAP. XXXI.

How to take the Plot of a Wood, Park, or other large Champaign plain by the Plain Table, by measuring round about the same, and making observation at every angle,

Hitherto we have shewed how the plot of any plain and even ground, or any small enclosure may be taken severall wayes, as being the easiest for a practitioner to try experience upon, I now come to shew how the plot of any large Champion plain, or over-grown wood may be measured, for in such kinde of grounds the former directions will be of little validity, for the largenesse of the plain, or the thicknesse of the wood may many times hinder both your sight and measuring; therefore the best way to measure these kinde of Lands is to go about them, and make observation at every angle.

Sap-

Suppose the following figure A B C D E F G to be a large Wood or other Champion plain, whose Plot you desire to take upon your Plain Table.

1. Place your Instrument at the angle A, directing your sights to the next angle at B, and by the side thereof draw a line upon your Table, as the line A B, then measure by the hedge side from the angle A to the angle B, which suppose 12 Chains 5 Links, then from your Scale take 12 Chains 5 Links; and set that distance upon your Table from A to B.

2. Remove your Instrument from A, and set up a mark where it last stood; and place your Instrument at the second angle at B, then laying the Index upon the line A B, turn the whole Instrument about till through the back-sights you see the mark which you set up at A, and there screw the Instrument: then laying the Index upon the point B, direct your sights to the third angle at C, and draw the line B C upon your Table, then measuring the distance B C 4 Chains 45 Links, take that distance from your Scale and set it upon your Table from B to C.

3. Remove your Instrument from B, and set up a mark in the room thereof, and place your Instrument at C, laying the Index upon the line C B, and turn the whole Instrument about till through the back-sights you espie your mark set up at B, and there fasten the Instrument: then laying the Index on the point C, direct the sights to D, and draw upon your Table the line C D, then measure from C to D 8 Chains 85 Links, and set that distance upon your Table from C to D.

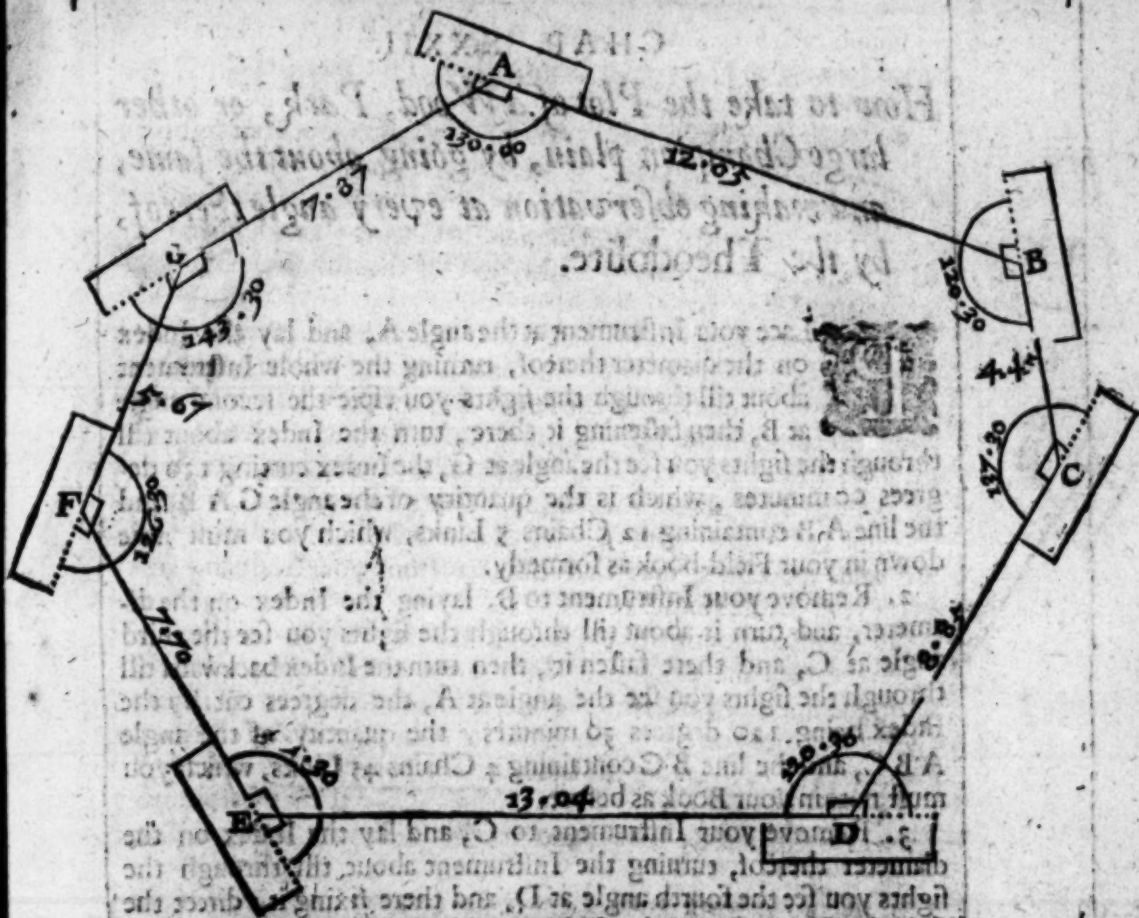
4. Remove your Instrument to D (placing a mark at C where it last stood) and lay the Index upon the line D C, turning the whole Instrument about till through the back-sights you espie the mark at C, and there fasten the Instrument: then lay the Index on the point D, and direct the sights to E, and draw the line D E, then with your Chain measure the distance D E 13 Chains 4 Links, and set that distance upon your Table from the point D unto E.

5. Remove your Instrument to E (placing a mark at D where it last stood) and laying the Index upon the line D E, turn the whole Instrument about till through the back-sights you see your mark at D, and there fasten the Instrument: then lay the Index on the point E, and direct the sights to F, and draw the line E F, then measure the distance E F 7 Chains 70 Links, which take from your Scale, and set it on your Table from E to F.

6. Remove your Instrument to F (placing a mark at E where it last stood) and lay the Index upon the line E F, turning the Instrument about till through the back-sights you see your mark set up at E, and there fasten the Instrument: then laying the Index on the point F, direct the sights to G, and draw the line F G upon your Table, then measure the distance F G 5 Chains 67 Links, and set that off upon your Table from F to G.

7. Remove your Instrument to G (setting up a mark at F where it last stood) and lay the Index upon the line F G, turning the whole

Instru-



Instrument about, till through the sights you see the mark in F, and there fasten the Instrument; then laying the Index upon the point G direct the sights to A (your first mark) and draw the line G A, which shall pass directly through the point A, where you first began, if you have truly wrought.

In this manner may you take the plot of any Champion plain be it never so large, and here note, that many times, hedges are of such a thickness that you cannot come near the sides or angles of the field, either to place your Instrument or measure your lines; therefore, in such cases, you must place your Instrument, and measure your lines parallel to the side thereof, and then your work will be the same as if you measured the hedges it self.

Note also, that in thus going about a field, you may much help your self by the Needle; for look what degree of the Card the needle cuts at one station, if you remove your Instrument to the next station, and with your back sights look to the mark where your Instrument last stood, you shall find the Needle to cut the same degree again, which will give you no small satisfaction in the prosecution of your work.

FINIS.

CHAP. XXXII.

How to take the Plot of a Wood, Park, or other large Champion plain, by going about the same, and making observation at every angle thereof, by the Theodolite.

Place your Instrument at the angle A, and lay the Index on the diameter thereof, turning the whole Instrument about till through the sights you espie the second angle at B, then fastening it there, turn the Index about till through the sights you see the angle at G, the Index cutting 130 degrees 00 minutes, which is the quantity of the angle G A B, and the line A B containing 12 Chains 5 Links, which you must note down in your Field-book as formerly.

2. Remove your Instrument to B, laying the Index on the diameter, and turn it about till through the sights you see the third angle at C, and there fasten it, then turn the Index backward till through the sights you see the angle at A, the degrees cut by the Index being 120 degrees 30 minutes, the quantity of the angle A B C, and the line B C containing 4 Chains 45 Links, which you must note in your Book as before.

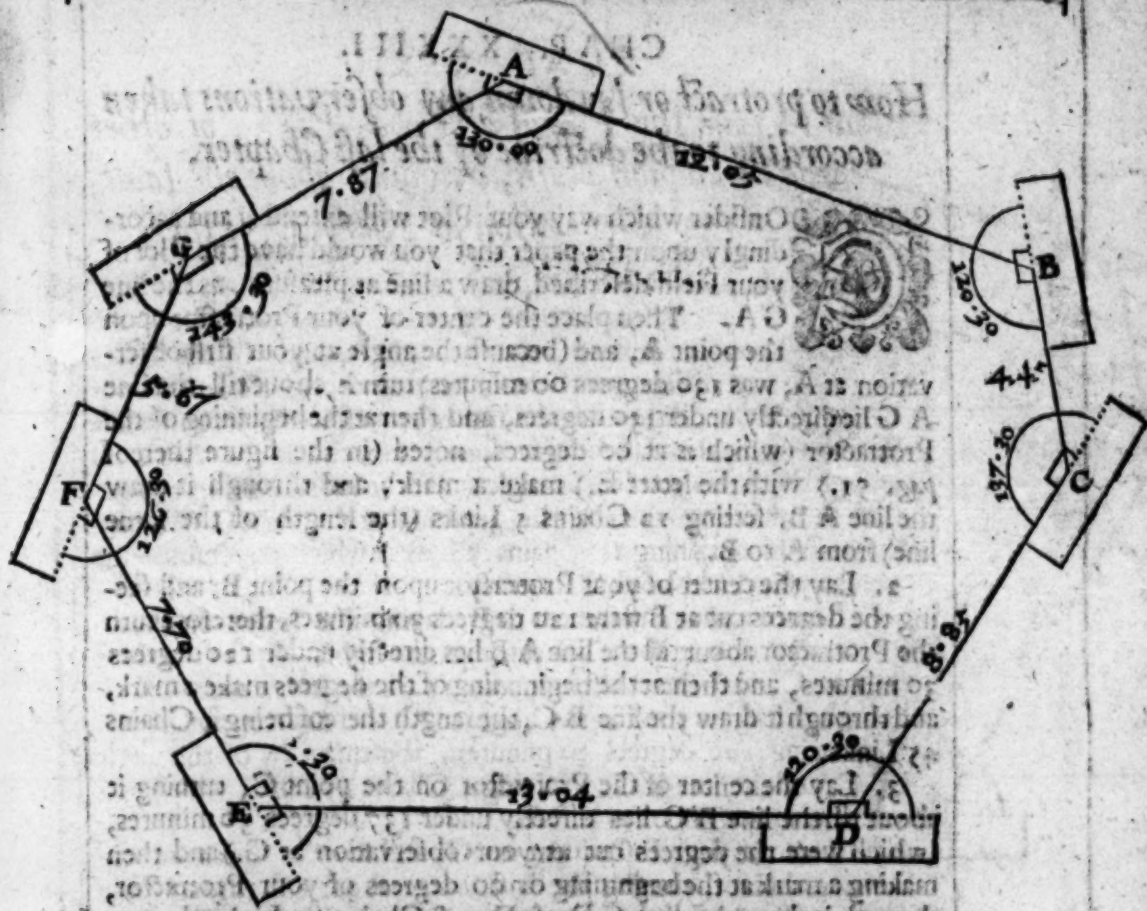
3. Remove your Instrument to C, and lay the Index on the diameter thereof, turning the Instrument about till through the sights you see the fourth angle at D, and there fixing it, direct the sights back again to B, the Index cutting 137 degrees 30 minutes, and the line C D being 8 Chains 65 Links.

4. Place your Instrument at D, and lay the Index on the Diameter, turning the Instrument about, till through the sights you espie the fifth angle at E, and there fixing it, turn the Index backward towards C, the degrees cut thereby being 120 degrees 30 minutes, and the line D E 13 Chains 4 Links, which must be noted in your Field-book.

5. Remove your Instrument to E, and lay the Index on the Diameter thereof, turning the Instrument about till through the sights you see the angle at F, and there fixing it, turn the Index backward to D, the degrees cut being 121 degrees 30 minutes, and the line E F 7 Chains 70 Links, which note down also.

6. Place your Instrument at F, and lay the Index on the Diameter thereof, turning the Instrument about till through the sights you see the angle at G, and there fixing it, turn the Index till through the sights you espie the former angle at B, the degrees cut being 126 degrees 30 minutes, and the length of the line F G being 5 Chains 67 Links.

7. Lastly




7. Lastly, Place the Instrument at G, and lay the Index on the Diameter, turning the whole Instrument about till through the sights you see the angle at A, and there fixing it, direct the sights back again to F, the degrees cut by the Index being 143 degrees 30 minutes, and the length of the line G A 7 Chains 87 Links.

Having thus made observation at every angle of the field in this manner, and collected the quantity of every angle, and the length of every line in your Field-book, you shall finde them to stand as followeth.

	Degrees	Minutes	Chains	Links
A	130	00	13	5
B	120	30	4	45
C	137	30	8	85
D	130	00	13	4
E	131	00	7	70
F	124	30	5	67
G	143	30	7	87

CHAP. XXXIII.

How to protract or lay down any observations taken according to the doctrine of the last Chapter.

 Consider which way your Plot will extend, and accordingly upon the paper that you would have the Plot of your Field described, draw a line at pleasure, as the line G A. Then place the center of your Protractor upon the point A, and (because the angle at your first observation at A, was 130 degrees 00 minutes) turn it about till the line A G lie directly under 130 degrees, and then at the beginning of the Protractor (which is at 00 degrees, noted (in the figure thereof pag. 51.) with the letter E,) make a mark, and through it draw the line A B, setting 12 Chains 5 Links (the length of the same line) from A to B.

2. Lay the center of your Protractor upon the point B, and seeing the degrees cut at B were 120 degrees 30 minutes, therefore turn the Protractor about till the line A B lies directly under 120 degrees 30 minutes, and then at the beginning of the degrees make a mark, and through it draw the line B C, the length thereof being 4 Chains 45 Links.

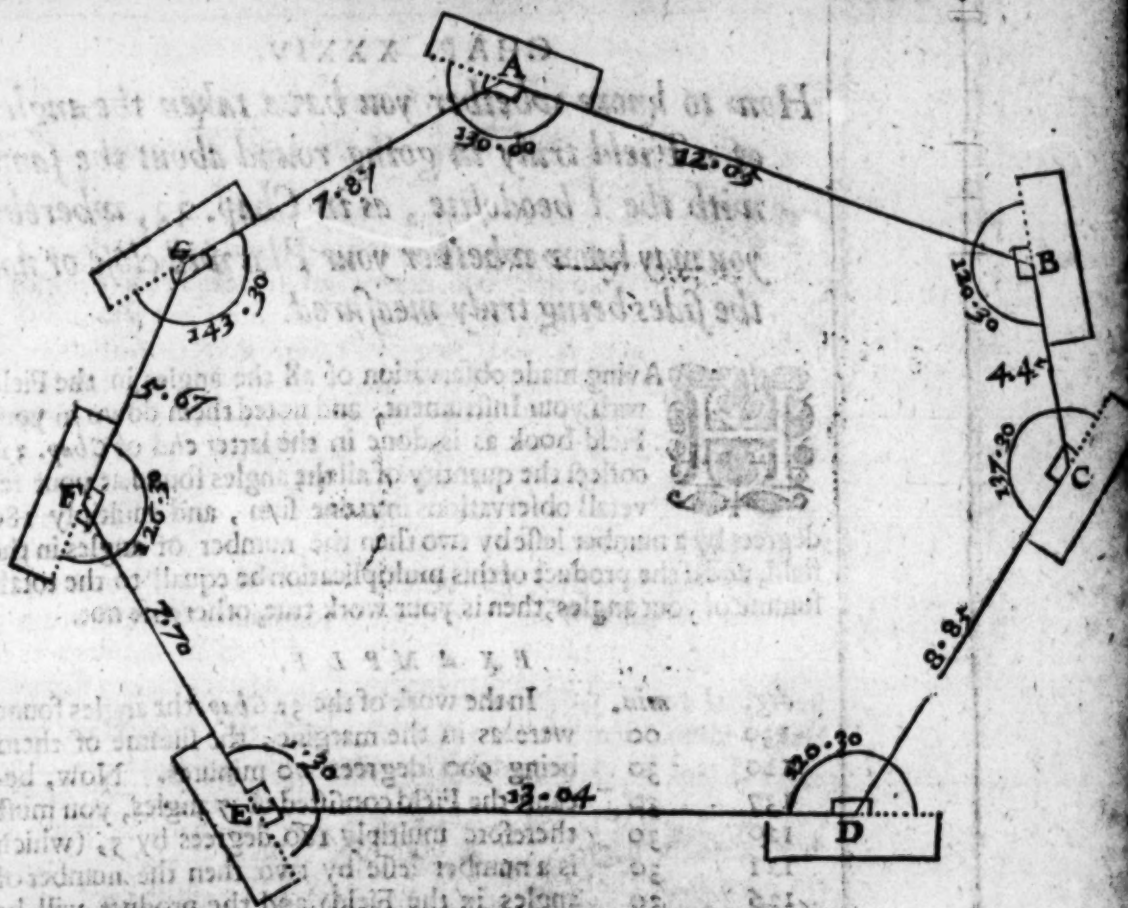
3. Lay the center of the Protractor on the point C, turning it about till the line B C lies directly under 137 degrees 30 minutes, (which were the degrees cut at your observation at C,) and then making a mark at the beginning or 00 degrees of your Protractor, through it draw the line C D, setting 8 Chains 85 Links thereon from C to D.

4. Bring the center of your Protractor to the point D, turning it about till the line C D lies directly under 130 degrees 30 minutes, and then making a mark at the beginning of the Protractor, through it draw the line D E, and upon it set 13 Chains 4 Links, from D to E.

In this manner must you deal with all the rest of the angles, and when you come to protract the angle at F, which is the last angle, and have drawn the line F G, you shall finde it to cut the line A G first drawn in the point G, leaving the line A G to contain 7 Chains 87 Links, and the line F G 5 Chains 67 Links; and in this, practise is better then many words, and the sight of the figure better then a whole Chapter of information, in which figure you may see the Protractor lie at every angle in its true position.

This work may be performed otherwise, by protracting your last observation first, so having drawn the line A G, lay the center of the Protractor on G, and the Meridian line thereof (namely E F) on the line G A, then (because the degrees cut at your observation at G were 143 degrees 30 minutes) make a mark with your protracting pin against 143 degrees 30 minutes, and through it draw the line G F, upon which line from G to F, set 5 Chains 67 Links.

Then



Then placing the center of your Protractor on the point F, and the Meridian line thereof upon the line F G, making a mark by the edge of the Protractor against 126 degrees 30 minutes (which were the degrees cut by the Index at your observation at F) and through that point draw the line F E, setting 7 Chains 70 Links thereupon from F to E.

And in this manner must you proceed with the rest of the lines and angles, and at last you shall finde the plot of your field to close at A, as before it did at G, and if the sides and angles were never so many, the manner of the work would be the same.

Here note that if in going about a field, and measuring the angles thereof with the Theodolite or degrees on the frame of the Table (as in Chap. 39.) that if you meet with any angle that bendeth inwards in the Field, you must reckon that angle to be so much above 180 degrees as the bending is, and when you note the degrees of such an angle in your Field-book, you may make this > or the like mark against them for a remembrance when you come to protract, and in protracting you must turn the Semicircle of the Protractor the contrary way to what you do in protracting of other angles.

CHAP. XXXIV.

How to know whether you have taken the angles of a Field truly in going round about the same with the Theodolite, as in Chap. 33, whereby you may know whether your Plot will close or not the sides being truly measured.



Having made observation of all the angles in the Field with your Instrument, and noted them down in your Field-book as is done in the latter end of Chap. 32. collect the quantity of all the angles found at your severall observations into one sum, and multiply 180 degrees by a number lesse by two then the number of angles in the field, and if the product of this multiplication be equall to the totall summe of your angles, then is your work true, otherwise not.

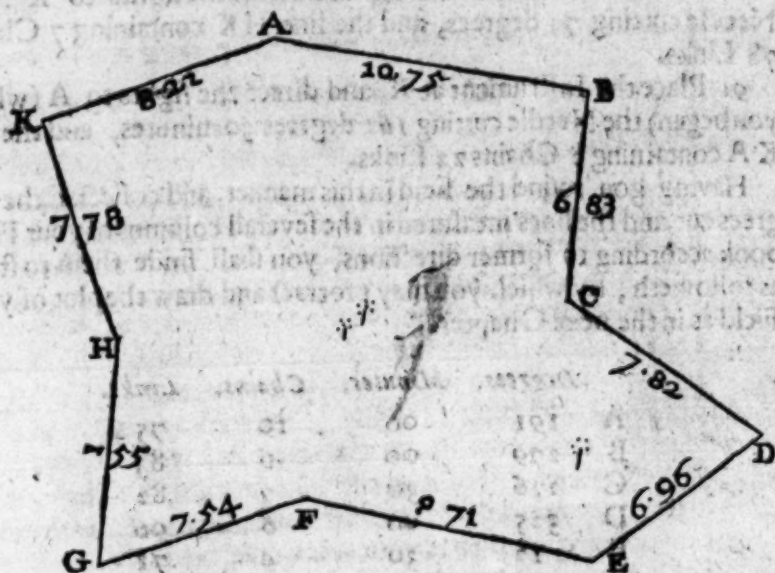
EXAMPLE.

deg.	min.	In the work of the 32 Chap. the angles found
130	00	were as in the margine, the summe of them
120	30	being 900 degrees 00 minutes. Now, be-
137	30	cause the Field consisted of 7 angles, you must
120	30	therefore multiply 180 degrees by 5, (which
121	30	is a number lesse by two then the number of
126	30	angles in the Field) and the product will be
143	30	900, which exactly agreeing with the summe
900	00	of all the angles in the Field as you found them
		by observation, you may conclude that your
		work is exactly performed.

CHAP. XXXV.

How to take the Plot of any Wood, Park, or other large Champaign plain, by going about the same, and making observation at every angle thereof, by the Circumferentor.

We have before shewn the use of the Circumferentor in taking the plot of any small inclosure severall wayes, but for those kinde of places the Circumferentor is no convenient Instrument; the use thereof in those works was only intimated, that the agreement of the severall Instruments in the performance of the same thing, might the better appear. Now the Circumferentor is



is a most absolute Instrument for the surveying of any large and spacious business, as a Park, Wood, or other large Common field or Champion plain, the use thereof differing from all that hath hitherto been delivered.

Suppose then that ABCDEFGHK were a large field or other inclosure to be plotted by the Circumferentor.

1. Place your Instrument at A (the Flower-de-luce towards you) direct the sights to B, the South end of the Needle cutting 101 degrees, and the ditch, wall or hedge AB containing 10 Chains 75 Links, the degrees cut, and the line measured, must be noted down in your Field-book as in the foregoing examples.

2. Place your Instrument at B, and direct the sights to C, the South end of the Needle cutting 127 degrees, and the line BC containing 6 Chains 83 Links, which note down in your Field-book as before.

3. Place the Instrument at C, and direct the sights to D, the Needle cutting 116 degrees 30 minutes, and the line CD containing 7 Chains 82 Links.

4. Place the Instrument at D, and direct the sights to E, the needle cutting 125 degrees, and the line DE containing 6 Chains 96 Links.

5. Place the Instrument at E, and direct the sights to F, the Needle cutting 123 degrees 30 minutes, and the line EF containing 9 Chains 71 Links.

6. Place the Instrument at F, and direct the sights to G, the Needle cutting 132 degrees 30 minutes, and the line FG containing 7 Chains 54 Links.

7. Place the Instrument at G, and direct the sights to H, the Needle cutting 128 degrees 30 minutes, and the line GH containing 7 Chains 52 Links.

8. Place

8. Place the Instrument at H, and direct the sights to K, the Needle cutting 71 degrees, and the line HK containing 7 Chains 78 Links.

9. Place the Instrument at K, and direct the sights to A (where you began) the Needle cutting 161 degrees 30 minutes, and the line KA containing 8 Chains 22 Links.

Having gon round the field in this manner, and collected the degrees cut, and the lines measured in the severall columns of your Field book according to former directions, you shall finde them to stand as followeth, by which you may protract and draw the plot of your Field as in the next Chapter.

Degrees. Minutes. Chains. Links.

A	191	00	10	75
B	279	00	6	83
C	216	30	7	82
D	325	00	6	96
E	12	30	9	71
F	342	30	7	54
G	98	30	7	54
H	71	00	7	78
K	161	30	8	22

In going about a field in this manner, you may perceive a wonderfull quick dispatch, for you are only to take notice of the degrees cut once at every angle, and not to use any back-sights as in the foregoing work of the Theodolite: but to use back-sights with the Circumferentor is best for to confirm your work, for when you stand at any angle of a field, and direct your sights to the next, and observe what degrees the South end of the needle cutteth, if you remove your Instrument from this angle to the next, and look to the mark or angle where it last stood, with your back-sights, the Needle will there also cut the same degree as before, which ought to be done, and may be, without much losse of time.

So the Instrument being placed at A if you direct the sights to B, you shall finde the Needle to cut 191 degrees, then removing your Instrument to B, if you direct the back-sights to A, the Needle will then also cut 191 degrees.

Now for dispatch and exactness (if the Needle be good, the Card well divided, and the degrees (by a good eye) truly estimated) the Circumferentor, for large and spacious grounds is as good as any, and therefore observe well the manner of protracting.

CHAP.

Your paper or parchment being thus prepared, affixe any point upon any of the Meridians, as A, upon which point place the centre of your Circumferentor, laying the Meridian line thereof, as you see it in the figure, then draw the line L M, and parallel thereto, draw divers other lines, quite through the whole paper or parchment, as the pricked lines in the figure drawn between L M and N O, and let the distance of each of these parallels one from another be somewhat lesse then the breadth of the Scale of your Protractor. These parallel lines thus drawn do represent Meridians, and are hereafter so called, upon one or other of these lines (or parallel to one of them) the Meridian line of your Protractor, noted in the figure thereof p. 51, with E F) must alwayes be laid when you protract any observations taken by the Circumferentor as in the Chapter before going.

CHAP. XXXVI.
How to protract any observations taken by the Circumferentor, according to the doctrine of the last Chapter.

According to the largeness of your Plot provide a sheet of paper or skin of parchment, as L M N O, upon which draw the line L M, and parallel thereto, draw divers other lines, quite through the whole paper or parchment, as the pricked lines in the figure drawn between L M and N O, and let the distance of each of these parallels one from another be somewhat lesse then the breadth of the Scale of your Protractor. These parallel lines thus drawn do represent Meridians, and are hereafter so called, upon one or other of these lines (or parallel to one of them) the Meridian line of your Protractor, noted in the figure thereof p. 51, with E F) must alwayes be laid when you protract any observations taken by the Circumferentor as in the Chapter before going.

Hh

Your

Your paper or parchment being thus prepared, assigne any point upon any of the Meridians, as A, upon which point place the center of your Protractor, laying the Meridian line thereof just upon the Meridian line drawn upon your paper, as you see it lie in the figure annexed. Then looke in your Field-book what degrees the needle cut at A, which were 191 degrees, now, because the degrees were more then 180, you must therefore lay the semicircle of the Protractor downwards, and holding it there, with your protracting pin make a mark against 191 degrees, through which point, from A, draw the line A B, which contains 10 Chains 73 Links.

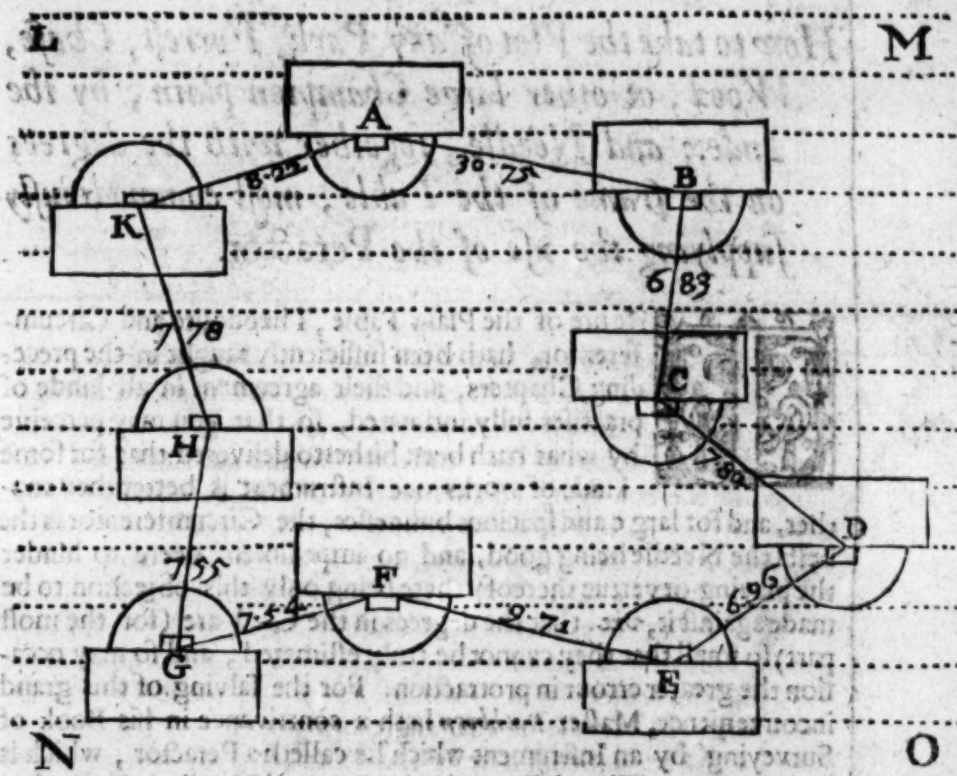
2. Lay the center of the Protractor on the point B, with the meridian line thereof parallel to one of the pricked Meridians drawn upon the paper, and seeing the degrees cut at B were more then 180, viz. 179, therefore the Semicircle must lie downwards, and so holding it, make a mark against 179 degrees, and through it draw the line B C, containing 6 Chains 83 Links.

3. Place the center of the Protractor on the point C, the Meridian line thereof lying parallel to one of the pricked Meridians drawn on the paper, then the degrees cut by the Needle at your third observation at C being above 180, namely 116 degrees 30 minutes, therefore must the Semicircle lie downwards, then making a mark against 116 degrees 30 minutes, through it draw the line C D, containing 7 Chains 82 Links.

4. Lay the center of the Protractor upon the point D, the degrees cut by the Needle at that angle being 325, which, being above 180, lay the Semicircle of the Protractor downwards, and against 325 degrees make a mark with your protracting pin, through which point, and the angle D, draw the line D E, making it to contain 6 Chains 98 links.

5. Remove your Protractor to E, laying the Meridian line thereof upon (or parallel to) one of the Meridians drawn upon your paper, and because the degrees cut by the Needle at this angle were less then 180, namely, 12 degrees 30 minutes, therefore, lay the Semicircle of the Protractor upwards, and make a mark against 12 degrees 30 minutes, through which draw the line E F, containing 9 Chains 71 Links.

6. Lay



6. Lay the center of the Protractor upon the point F, and because the degrees to be protracted are above 180, viz. 342 degrees 30 minutes, lay the Semicircle of the Protractor downwards, and make a mark against 342 degrees 30 minutes, drawing the line F.G which contains 7 Chains 54 Links.

And in this manner must you protract all the other angles G, H, and K, and more, if the field had consisted of more angles, always observing this for a generall rule, to lay the meridian line of the Protractor upon (or parallel to) one of the Meridians drawn upon your paper (which the small divisions at each end of the Scale of the Protractor will help you to do,) and if the degrees you are to protract be lesse then 180 (as those at G H and K are) to lay the Semicircle of the Protractor upwards, or from you, and if they be above 180 degrees (as those at A B C and D are) to lay the Semicircle downwards, as you see done in the figure.

CHAP. XXXVII.

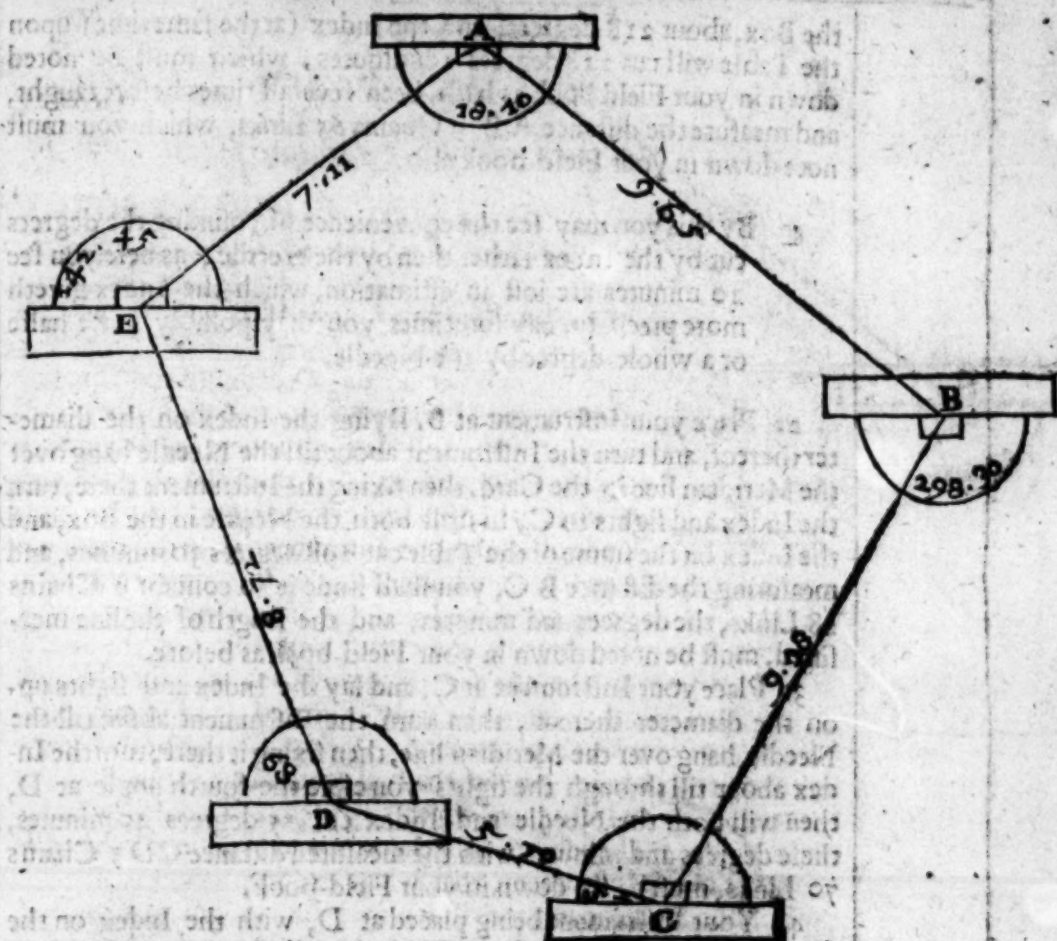
How to take the Plot of any Park, Forrest, Chase, Wood, or other large Champion plain, by the Index and Needle, together with the degrees on the frame of the Table, most commodiously supplying the use of the Peractor.



The use of the Plain Table, Theodolite and Circumferentor, hath been sufficiently taught in the preceding Chapters, and their agreement in all kinde of practises fully intimated, so that you may perceive by what hath been hitherto delivered, that for some kinde of works one Instrument is better then another, and for large and spacious businesses, the Circumferentor is the best (the Needle being good, and no impediment neere to hinder the playing or vertue thereof) there being only this objection to be made against it, *viz.* that the degrees in the Card are (for the most part) so small that they cannot be truly estimated, and so may occasion the greater error in protraction. For the salving of this grand inconvenience, Master *Rashborn* hath a contrivance in his Book of Surveying (by an Instrument which he calleth a Peractor, which is no other then a Theodolite, only the Box and Needle is so fitted to the center of the Instrument, that when the Instrument is fixed in any position whatsoever, the Index may be turned about, and yet the Box and Needle remain immovable. The benefit of this contrivance is, that whereas in the Circumferentor the degrees are cut by the Needle, here the same degrees are cut by the Index, and therefore are larger, the use whereof is this.

Place the Peractor at any angle of a field, and turn it about till the Needle hang directly over the Meridian line in the Card, then fix the Instrument there, and turn the Index about till through the sights you espie the mark or angle you would looke at, then shall the Index cut the same degrees and minutes upon the Limbe of the Peractor, as the Needle would have cut upon the Card of the Circumferentor, if used as is before taught: yet notwithstanding this contrivance, you see you must be beholding to the Needle, the convenience only being, that the degrees which you are to note in your Field-book, are larger upon the limb of the Instrument then in the Card, which (I confesse) is something considerable.

Now if any man have a desire to make use of this Instrument, thinking none better, he is much deceived, for the Box and Needle being screwed to the Index of the Plain Table, and fastned to the center of the degrees upon the frame of the Table, performeth the work of the Peractor much better then the Peractor it selfe, for, whereas in the use of the Peractor, you alwayes let the needle hang over



over the meridian line, and let the Index cut the degrees, in this you shall see that in going round a field, the Needle in the Card, and the Index on the frame of the Table will cut like degrees, so that you have a double testimonie for every observation with the same facility, which is no small satisfaction. Now because (I know) there are some which are wedded to the use of this Instrument, and induce all men whom they can perswade to the use thereof, thinking none so good, or at least better, I will here in one example briefly shew the use thereof, as it is to be performed by the degrees projected on the frame of the Plain-Table, and thereby make the Plain Table more general.

Let $ABCDE$ be a Field to be measured by the Index and Needle on the Plain Table, supplying the use of the Perforator.

1. Place your Instrument at A , laying the Index and sights with the Box and Needle screwed thereto upon the Diameter of the Table, then the Index so lying, turn the whole Instrument about till the Needle hang directly over the Meridian line in the Card, then screw the Instrument fast, and turn the Index about upon the center, till through the sights you espie your second angle at B , then you shall see that the South end of the Needle will cut upon the Card in the

the Box, about 218 degrees, and the Index (at the same time) upon the Table will cut 218 degrees 10 minutes, which must be noted down in your Field book as hath been severall times before taught, and measure the distance A B, 9 Chains 65 Links, which you must note down in your Field-book also.

- ☐ By this you may see the convenience of counting the degrees cut by the Index rather then by the Needle, as here you see 10 minutes are lost in estimation, which the Index giveth more precisely, nay sometimes you may possibly misse halfe or a whole degree by the Needle.

2. Place your Instrument at B, laying the Index on the diameter thereof, and turn the Instrument about till the Needle hang over the Meridian line in the Card, then fixing the Instrument there, turn the Index and sights to C, so shall both the Needle in the Box, and the Index on the frame of the Table cut 298 degrees 30 minutes, and measuring the distance B C, you shall finde it to contain 9 Chains 28 Links, the degrees and minutes, and the length of the line measured, must be noted down in your Field-book as before.

3. Place your Instrument at C, and lay the Index and sights upon the diameter thereof, then turn the Instrument about till the Needle hang over the Meridian line, then fixing it there, turn the Index about till through the sights you espie the fourth angle at D, then will both the Needle and Index cut 15 degrees 40 minutes, these degrees and minutes, with the measured distance CD 5 Chains 70 Links, must be set down in your Field-book.

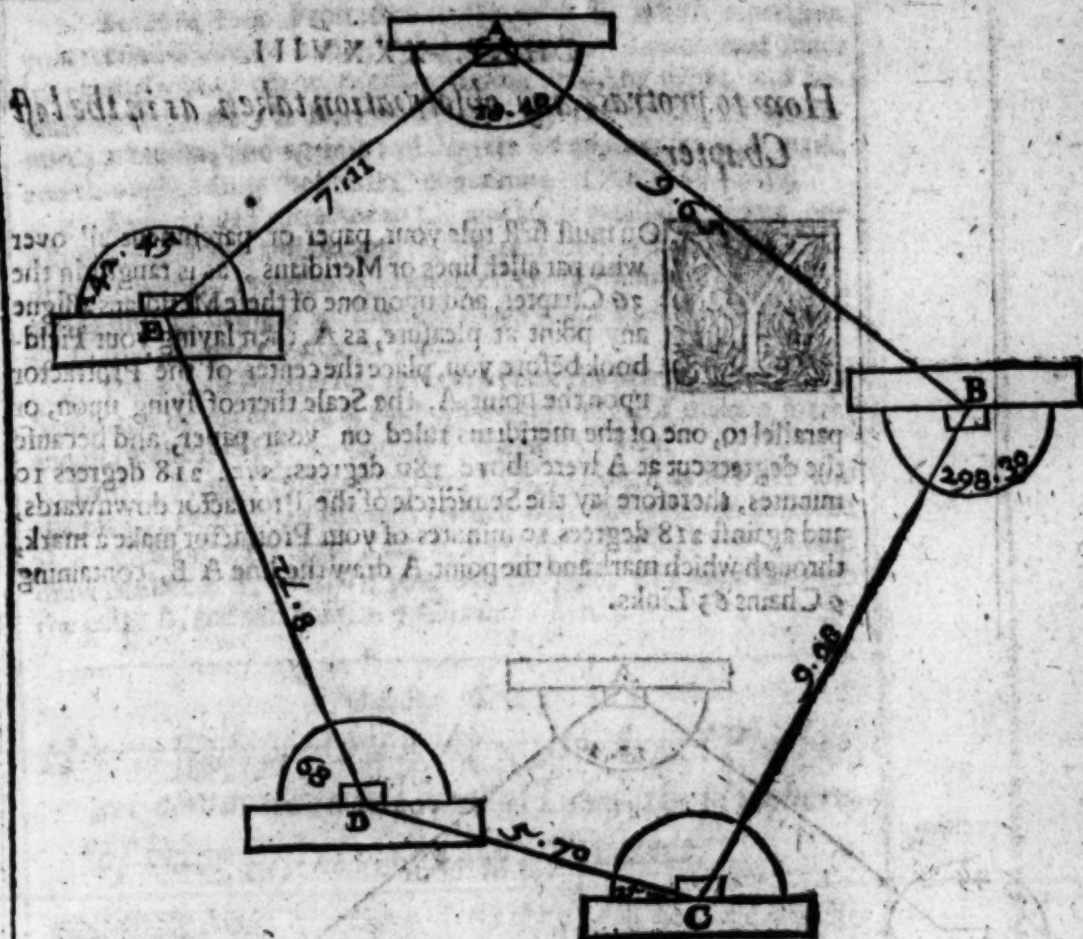
4. Your Instrument being placed at D, with the Index on the diameter thereof, turn it about till the Needle hang over the Meridian line, and there fixing it, turn the Index about till through the sights you see the next angle at E, then will both the Needle and Index cut 68 degrees, and the distance D E will be 8 Chains 73 Links, which note in your Field-book as before.

5. Lastly, place your Instrument at E (observing all the former cautions) and direct the sights to A, where you shall finde both the Needle and Index to cut 142 degrees 45 minutes, and the measured distance E A to be 7 Chains 11 Links, which note down in your Field-book.

And thus may you go about any field, let it consist of never so many sides and angles, observing alwayes this generall rule, to lay the Index with the Box and Needle, on the diameter of the Table, and to turn the Table about till the Needle hangs directly over the meridian line in the Card, and then fixing the Table, turn the Index about till through the sights you espie the mark you looke for, then will both the Index and the Needle cut the degrees which you must note in your Field-book, so will the collected notes of this example stand as followeth.

And thus may you go about any field, let it consist of never so many sides and angles, observing alwayes this generall rule, to lay the Index with the Box and Needle, on the diameter of the Table, and to turn the Table about till the Needle hangs directly over the meridian line in the Card, and then fixing the Table, turn the Index about till through the sights you espie the mark you looke for, then will both the Index and the Needle cut the degrees which you must note in your Field-book, so will the collected notes of this example stand as followeth.

Degrees



Degrees	Minutes	Chains	Links
A 118	10	9	65
B 298	30	9	38
C 15	40	5	70
D 68	00	8	71
E 143	45	7	11

Having thus collected your severall observations, you may proceed to protract your work as is taught in the next Chapter, which differeth nothing from that in the 36 Chap.

It will be here objected by the affectors of the Peractur, that here it is required that the Needle should play twice at each observation, to which I answer, it is true, but if you neglect the latter of them, it is both as speedy and as exact as the Peractur, and if you have opportunity to observe both (which you may conveniently do) it will then be better.

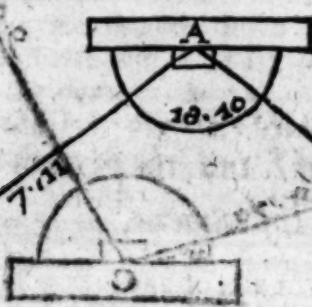
CHAP.

CHAP. XXXVIII.

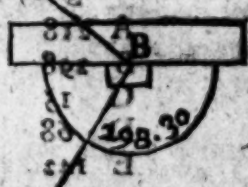
How to protract any observation taken as in the last Chapter.



You must first rule your paper or parchment all over with parallel lines or Meridians, as is taught in the 36 Chapter, and upon one of these Meridians assigne any point at pleasure, as A, then laying your Field-book before you, place the center of the Protractor upon the point A, the Scale thereof lying upon, or parallel to, one of the meridians ruled on your paper, and because the degrees cut at A were above 180 degrees, viz. 218 degrees 10 minutes, therefore lay the Semicircle of the Protractor downwards, and against 218 degrees 10 minutes of your Protractor make a mark, through which mark and the point A draw the line A B, containing 9 Chains 65 Links.



Links	Chains	Minutes
65	9	10
28	2	30
20	2	40
25	2	50
11	2	10



Having thus collected your several observations, you may proceed to protract your book as is taught in the next Chapter, which is not difficult nothing from in the 36 Chapter.

It will be here objected by the objectors of the book, that there is required in the Table should have been added, the observation, to which I answer, it is true, but it is not the last of them, it is both as the book is written, which is better, and if you may conveniently observe both, which you may conveniently observe both.

CHAP.

21. Remove your Protractor to the point B, which represents your second Station or angle, lying the Meridian-line thereof upon (or parallel to) one of the Meridians drawn upon the paper, and because the degrees cut at B are above 180, lay the Semicircle downwards as before, and against 198 degrees 30 minutes make a mark, and through it draw the line B C containing 9 Chains 18 Links.

22. Bring your Protractor to C, and lay it parallel to some one of your Meridians, and because the degrees observed at C were under 180, namely 27 degrees 40 minutes, lay the Semicircle upwards, and against 25 degrees 40 minutes make a mark, drawing the line C D containing 1 Chain 90 Links.

23. Place your Protractor as before upon the point D, with the Semicircle upwards, and against 68 degrees thereof make a mark, and draw the line D E containing 8 Chains 72 Links.

24. Lastly, Remove your Protractor to E, placing it as before, and against 142 degrees 45 minutes (which were the degrees observed at your station at E) make a mark, and through it and the point F draw the line E A, which (if your work be true) will passe through the point A, and will contain 7 Chains 11 Links.

CHAP. XXXIX.

How to finde how many Acres, Roods and Perches, are contained in any piece of Land, the plot thereof being first taken by any Instrument.



Having shewn how to take the plot of any field or other Inclosure severall wayes, and also to protract the same upon paper, it is now necessary to shew how the content thereof may be attained, that is to say, how many Acres, Roods and Perches any field so plotted doth contain: In the performance hereof you must consider that the originall of the mensuration of all superficiall figures, such as Land, Board, Glasie or the like, doth depend upon the exact measuring of certain regular figures, as the Geometrical Square, the Long Square or Parallelogram, the Triangle, the Trapezium, and the Circle: therefore, if any plot of Land to be measured be not one of these figures, it must (before it can be measured) be reduced into some of these forms. I will therefore in the first place shew how to measure any of these figures severally by themselves, and afterwards how to reduce any other Irregular figure into some of these regular forms, and lastly to measure them by the same rules: and first,

Of the Geometrical Square.

A Geometrical Square is a figure consisting of four equall sides and angles, as is the Square A B C D, whose sides are all equall to the line Q R, which containeth six equall parts, which may be

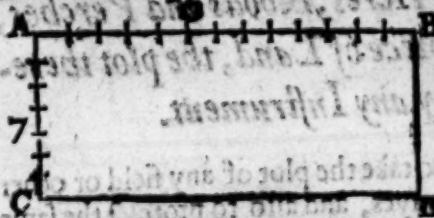
tributed either to Inches, Feet, Yards, Perches, Chains, or any other measure whatsoever.

Now, to finde the superficial content of such a Square, you must multiply one of the sides in it selfe, and the product of that multiplication shall be the content of the Square.

Suppose the Square ABCD to be a piece of Land, and the side, hereof to contain 6 Perches, as it therefore multiply 6 in it selfe, and the product will be 36, & so many Perches doth the square piece of Land contain.

Of the long Square.

A Long Square is a figure consisting of four sides, as the figure ABCD, the two opposite sides whereof are equal, as the sides AB, and CD, and likewise AC and BD, each of the shorter sides containing 7 Perches, and the longer sides 13 Perches.

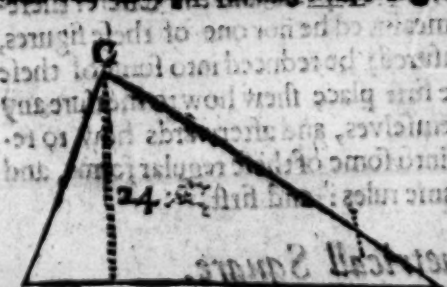


To finde the superficial content of this long Square or Parallelogram, you must multiply one of the longer sides by one of the shorter, and the product will shew the superficial content thereof.

Example, The longer side of the Square contains 13 perches, and the shorter 7 perches, now if you multiply 13 by 7, the product will be 91, and that is the content of the square in perches.

Of the Triangle.

Although there be severall kinds of Triangles, yet in respect they are all measured by one and the same rule, I will therefore add one example for all, which is general.



Halfe the length of the Base being multiplied by the length of the perpendicular, shall be a quick way to find the content of the triangle. Or, Halfe the length of the perpendicular being multiplied by the whole Base, will also shew the content of the triangle.

EXAMPLE.

Suppose you were to finde the area or content of the triangle BCD, the Base thereof DB containing 58 perches, and the perpendicular CA 24 perches.

Now

Now if you multiply 12 (which is half the length of the perpendicular C A) by 58 (the length of the whole base D B) the product will be 696 and that is the area or content of the Triangle.

Or, If you multiply 24 (the whole length of the perpendicular) by 29 (the length of half the base) the product will be 696 as before.

Or again: If you multiply 58 (the whole length of the base) by 12 (the whole length of the perpendicular) the product will be 1392, the half whereof is 696, the area or content of the Triangle, as before.

Of the Trapezia.

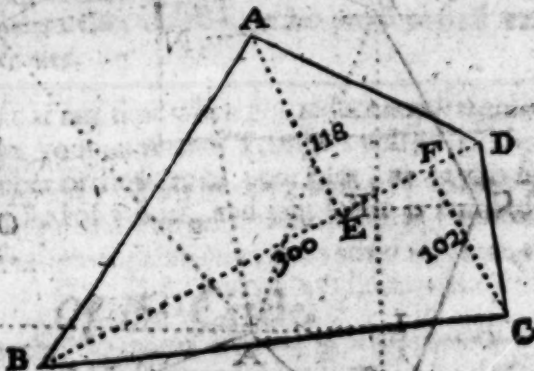
A Trapezia is a figure consisting of four unequal sides, and as many unequal angles, as is the figure A B C D.

To measure this Trapezia, you must first draw the diagonal line B D, for by this means the figure is reduced into two Triangles, as A D B, and C D B, then if you let fall the perpendiculars from the points A and C, you may measure them by the last examples, as two Triangles; the sums whereof being added together will be the area or content of the whole Trapezia.

EXAMPLE.

Having drawn the line B D, and so reduced the Trapezia into two Triangles, and let fall the perpendiculars A E and C F, upon the line B D, which is the common base to both the Triangles, you may find the area of the whole Trapezia, thus.

Suppose the perpendicular C F, were 102 perches, the perpendicular A E 118 perches, and the base B D (which is common to both Triangles) 300 perches.



Now, if according to former directions, you

multiply 300 the base, by 59 halfe the perpendicular A E, the product will be 17700, for the content of the Triangle A B D.

In like manner, if you multiply 300 the Base, by 51, halfe the perpendicular F C, the product will be 15300, for the content of the Triangle B C D.

Now if you add the contents of those two Triangles together, namely 17700 and 15300, the summe of them will be 33000, and that is the content of the whole Trapezia A B C D.

But this work may be performed with more brevity, thus.

In respect the Base B D is common to both the Triangles, you may therefore add the two perpendiculars together, the halfe of which being multiplied by the whole Base, the product will shew the content of the whole Trapezia.

EXAMPLE.

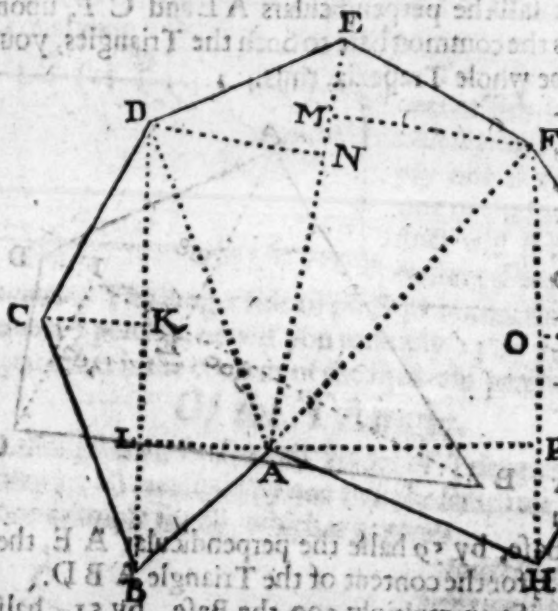
The two perpendiculars 118 and 102 being added together, the summe of them is 220, the halfe whereof is 110, this number being multiplied by 300 (the whole length of the common base) given 33000 the content of the whole Trapezia.

OR,

You may multiply the sum of the perpendiculars by the length of the Base, and halfe that product will be the content of the Trapezia also.

Of irregular Figures, how to reduce them into Triangles or Trapezias, and to cast up the content thereof.

L Et ABCDEFGH be the figure of a Field drawn upon your Plain Table, or otherwise protracted upon paper, according to any of the former directions.



In regard that the Field is irregular, that is to say, it is neither Square, Triangle, or Trapezia, it must therefore (before it can be measured) be reduced into some of these forms, which to effect do thus: draw lines from one angle to other, as the lines AD, DE, AE, AF, and FH, then will the whole figure be reduced into six Triangles, &c.

1. the Triangle BCD.
2. the Triangle ADB.
3. the Triangle ADE.
4. the Triangle AEF.
5. the Triangle AFH.
6. the Triangle FGH.

These

These six Triangles being measured severally, according to the former directions, and the contents of each, all added together into one summe, will shew the area or content of the whole field. As,

Suppose the Triangle $\left\{ \begin{array}{l} BCD \\ ADB \\ ADE \\ AEF \\ AFH \\ FGH \end{array} \right\}$ should contain $\left\{ \begin{array}{l} 72 \\ 84 \\ 110 \\ 131 \\ 165 \\ 66 \end{array} \right\}$ Perches.

These six numbers being added together make 618 perches, and that is the area or content of the whole Field in perches.

But for an abbreviation of this work, you need not to finde the area of every Triangle, but of every Trapezia, as is before taught, for the figure is as well divided into Trapezias as Triangles, namely, into the Trapezias ABCD, ADEF, AFGH,

By this means you neede but to finde the area or content of these three Trapezias, which will abbreviate nigh halfe of the Arithmetically work, for if you measure the three Trapezias severally, as hath been taught in this Chapter, you shall finde

The Trapezia $\left\{ \begin{array}{l} ABCD \\ ADEF \\ AFGH \end{array} \right\}$ to contain $\left\{ \begin{array}{l} 156 \\ 232 \\ 230 \end{array} \right\}$ Perches.

These three numbers being added together produce 618 exactly agreeing with the former.

¶ Here note, that at any time when you reduce any irregular plot into Triangles, your number of Triangles will be lesse by two then the number of the sides of your plot, as in this figure, the plot consisted of 8 sides, and you see it is reduced into 6 Triangles.

Of the Circle.

THe proportion of the circumference of any Circle is to its diameter, as 7 to 22.

Now to finde the area or content of any Circle, you must multiply the diameter thereof in it self, and multiply that sum by 11, which product being divided by 14, shall give you the area of the Circle.

EXAMPLE.

In this Circle ABCD, let the diameter thereof DB be 28, which multiplied in it self giveth 784, this number multiplied by 11 giveth 8624, which being divided by 14, the quotient will be 616, and that is the area of the Circle.



*The Circumference of a Circle being given, to
finde the Diameter.*

Multiply the Circumference by 7, and divide the product by 22, the Quotient shall be the length of the Diameter.

EXAMPLE.

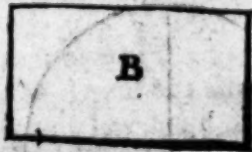
Let the circumference of the Circle A B C D be 88, this multiplied by 7, giveth 616, which being divided by 22, giveth 28 for the Diameter D B.

CHAP. XL.

*Of the manner of casting up the content of any piece
of Land in Acres, Roods and Perches, by Master
Rathborns Chain.*

IN the 5. Chapter of the 2 Book, you have a description of Chains in generall, and more particularly of Master Rathborns and Master Gunters. In the measuring of Land by Master Rathborns Chain, you call every Pole or Perch thereof (which is divided into 100 Links) a *Unit*, and every ten of those Links you call a *Prime*, and every single Link you call a *Second*.

Now because there are divers that fancie this Chain rather than any other, because it giveth the content of any Superficies measured therewith in its smallest denomination, namely in Perches and parts of Perches, so that when any Superficies is cast up and brought to Perches, it may easily be reduced into Roods and Acres. Now (for their sakes that affect this Chain) I will shew the use thereof, and afterwards of Master Gunters Chain, leaving every man to take his choice, and use that which liketh him best.



Suppose that the figure B were a piece of Land lying in a long square, which being measured by Master Rathborns Chain should contain in length 16 *Units*, 2 *Primes*, and in breadth 1 *Unit*, 3 *Primes*, 2 *Seconds*, and that it were required to

finde the area or content thereof in Perches, which to effect you must multiply the length by the breadth as is taught in the last Chapter, therefore, the length being 16 *Units* 2 *Primes*, and the breadth 1 *Unit*, 3 *Primes*, 2 *Seconds*, these two numbers multiplied together shall produce the area.

Set

Set your numbers down as you are taught in the 5 Chapter, of the 2 Book, or as you see them stand in this Example, with a prick over the head of every fraction: under these numbers draw a line, and multiply them together as if they were whole numbers, and then the work will stand thus, the product of your multiplication being

21384. Now because in your two numbers, viz. your multiplicand and your multiplier, there are three fractions, namely, one in your multiplicand, and two in your multiplier, you must therefore (with a dash of your pen) cut off the three last figures of the product towards your right hand, and then will your product stand thus, the three last figures whereof are the numerator of a fraction, whose denominator is 1000, and the other two figures towards your left hand are Integers of your multiplication, so that the sum of this multiplication is 21 perches, and $\frac{24}{1000}$ parts of a perch, which is something more than a third part of a perch.

But to expresse the exact quantity of these fractions in a business of this nature were superfluous, only observe this one Rule for all, namely, that if the figures cut off come neere to a Unite, that is, when the figures cut off are neere as much as those underneath them, or the first figure cut off is either 7, 8, or 9, you may then increase your whole number by a Unite, and not at all regard the fraction.

But for your further practise take another Example, which let be a piece of land containing in breadth 3 Unites, 6 Primes, 3 Seconds, and in length, 15 Unites, 4 Primes and 3 Seconds, which place as before.

Now if you multiply these numbers one by another as if they were whole numbers, then will they stand as in the margin; the product being 868146, from whence take the four last figures (because there are four fractions in your two numbers) there remains 86 perches, and $\frac{146}{10000}$ parts of a perch, now because 8146 is neere to 10000, I adde 1 to 86, making it 87 perches, dis-regarding the excess as immateriall.

In like manner, suppose the perpendicular of a Triangle should contain 1 Unite, 3 Primes, 3 Seconds, and half the length of the base should contain 16 Unites, 2 Primes, these numbers being placed as those before, and multiplied one by another, will produce this product 21384, from whence cut off the three last figures (because there were three fractions in your numbers multiplied) and there will remain 21 perches, and $\frac{384}{1000}$ parts of a perch, which being but of small value you may reject.

CHAP. XII.

How to reduce any number of Perches into Roods and Acres, or any number of Acres and Roods into Perches.

BY a Statute made the 33. of Edw. 1. an Acre of ground ought to contain 160 square Perches, and every Rood of Land 40 square Perches, and every Perch was to contain 16 foot and a halfe. Now, if any number of Perches be given to be turned into Acres, you must divide the number given by 160 (the number of perches contained in one Acre) and the quotient shall shew you how many Acres are contained in that number of Perches, and if any thing remain (if it be under 40) it is Perches, but if the remainder exceed 40, then you must divide it by 40 (the number of perches contained in one Rood) and the quotient shall be Roods, and the remainder perches.

EXAMPLE.

Let 5267 perches be given to be reduced into Acres, first, divide 5267 by 160, and the quotient will be 32, and 147 remaining, which divide by 40, the quotient will be 3, and 27 remaining, so that the whole amounteth to 32 Acres 3 Roods and 27 perches.

Again, let 5496 perches be given to be reduced into Acres, first, divide 5496 by 160, the quotient will be 34, and 56 remaining, which 56 being divided by 40, the quotient will be 1, and 16 remaining, so that the whole will be 34 Acres 1 Rood and 16 perches.

To reduce Acres into Perches.

THIS is but the converse of the former, for (as before) to reduce perches into Acres, you divided by 160, you must now, to reduce Acres into Perches, multiply by 160.

EXAMPLE.

Let 32 Acres 3 Roods and 27 perches, be given to be reduced into Perches: first, multiply the 32 Acres by 160, and the product will be 5120, then multiply the 3 Roods by 40, the product is 120, these two products, and the 27 perches being added together, the summe will be 5267, and so many perches are contained in the foresaid number of Acres, Roods and perches: and thus much concerning the use of Master Rabborns Chain.

CHAP. XLII.

How to cast up the content of any piece of Land in Acres, Roods and Perches, by Master Gunter's Chain.

IN measuring, by Master Gunter's Chain you are in your account only to take notice of Chains and Links, as was before intimated in the description thereof Chap. 5. Lib. 2. Suppose then that the figure B were a piece of Land lying in a long square, and that being measured by Master Gunter's Chain should contain in length 9 Chains 50 Links, and in breadth 6 Chains 25 Links.

Set your numbers down as before is taught and as here you see, drawing a line under them, then multiplying them together, you shall finde the product to be 593750. from which product you must alwayes cut off the five last figures towards the right hands with a dash of your pen, then will the product stand thus, 593750. so is the 5 towards the left hand complete Acres, and the 93750 hundred thousand parts of an Acre, which to reduce into Roods and Perches is easie, by help of this Table.

B		
9	50	
6	25	
<hr/>		
5	93750	
1	900	
<hr/>		
5	700	
<hr/>		
5	93750	

For, if you looke for 90000, under the title Links (which is the first figure with Cyphers added) you shall finde against it 3 Roods, 24 Perches, then looke for 3750, and against it you shall finde 6 perches, all which being added together as here you see, the area or content of the whole piece will be 5 Acres, 3 Roods and 30 Perches.

Links.	R.	P.
100000	4	0
90000	3	24
80000	3	8
70000	2	32
60000	2	16
50000	2	0
40000	1	24
30000	1	8
20000	0	34
10000	0	16
9375	0	15
8750	0	14
8125	0	13
7500	0	12
6875	0	11
6250	0	10
5625	0	9
5000	0	8
4375	0	7
3750	0	6
3125	0	5
2500	0	4
1875	0	3
1250	0	2
625	0	1

Another Example.

Suppose the base of a Triangle should contain 16 Chains 56 Links, and halfe the perpendicular of the same Triangle 4 Chains 32 Links, these being multiplied one in the other will produce the area or content of the whole Triangle.

K k

Set

16,56
4,32
3312
4968
6624
715392

Set your numbers down as in the margine is done, and multiply one by the other, so will the Product be 715392, from which cutting off the five last figures towards the right hand, there will be left before the line of partition 7, which is 7 complet Acres, and behinde the line there will be 15392, which are hundred thousand parts of an Acre, and how much that is, the Table will easily shew; for, if you looke in the first column for 10000, against it you shall finde 00 Roods 16 Perches, then looking for 5392, you finde it not, but the neereft thereto is 5625, against which there standeth 9 perches, all these numbers being added together will produce 7 Acres, 00 Roods, 27 Perches, which is the area of the Triangle.

Thus may you finde the area of any Triangle or Parallelogram very easily by one multiplication and addition, which is much easier then the way of casting up by Master *Rashbourns* Chain.

By this manner of work if the length and breadth of a long Square or Parallelogram given should be 9 Chains 75 Links, and 6 Chains 25 Links, the area of such a long Square would be found to be 6 Acres, 00 Roods 15 perches. Or, the length and breadth being 12 Chains 42 Links, and 1 Chain 36 Links, the area or content will be found to be 1 Acre, 2 Roods, 30 perches. Also, the length and breadth being 12 Chains 86 Links, and 5 Chains 25 Links, the area will be found to be 6 Acres, 3 Roods, 00 perches.

But lest you should be destitute of this Table when you have need thereof, you may have it put upon some spare place of your Instrument, or rather (instead of this Table) a Scale, which I will now shew you the use of, which performeth that work far better and more easily then the Table, and may conveniently be graduated upon the Index of your Table, the dividing and numbering whereof is well known to the Instrument maker.

The Scale consisteth of two parts, one whereof is square perches, the other square Links, the Scale of square perches proceedeth gradually from 1 to 40 with sub-divisions, and is numbered by 5, 10, 15, 20, &c. to 40. The Scale of square Links proceedeth gradually from 1 to 25000, and is also sub-divided and numbered by 1000, 2000, &c. to 25000, equall to 1 Rood or 40 perches.

The use of the Scale of Reduction.

We will instance in the second example beforegoing, where the length and breadth of the long Square was 16 Chains 56 Links, and 4 Chains 32 Links, these being multiplyed together produces 715392, and the five last figures being cut off, there is 7 Acres and 15392 remaining, now to finde how many Roods and Perches this is, look in the Scale of Square Links for fifteen thousand three hundred ninety two, and against it, in the Scale of square Perches you shall finde 24 Perches and above halfe a perch.

Another

Another Example.

Let us take the first example beforegoing, where the numbers multiplyed were 9.50, and 6.25, these being multiplyed one by another produce 593750, and the five last figures being cut off, there will be 5 Acres, and 93750 remaining: now to know how many Roods and Perches are contained therein by the Scale,

C You must consider that 25000 square Links are equal to one Rood or 40 Perches, as appeareth by the Scale it selfe, and also by the Table, then is 50000 equal to 2 Roods, and 75000 equal to 3 Roods; therefore, if your number remaining exceed 25000, and be under 50000, you may conclude 1 Rood and odde perches to be contained therein. If it exceed 50000, and be under 75000, you may conclude 2 Roods and some odde perches to be therein. If above 75000, you may then conclude 3 Roods and odde perches to be therein.

Now in this example, the number remaining is 93750, which because it exceedeth 75000, I conclude there is 3 Roods contained therein, which I set to the 5 Acres, and subtract 75000 from 93750, the remainder being 18750, this number, eighteen thousand seven hundred and fifty, I seeke in the Scale of Square Links, and right against it I finde 30 perches, which added to the former, giveth 5 Acres, 3 Roods and 30 Perches, which is the area or content required.

Thus you see with what celerity and exactnesse the Scale effecteth your desire, and therefore let it be graduated upon the Index of your Table that it may alwayes be ready at hand when you have need thereof. The construction of this Reducing Scale I received of my honoured friend Master S. F. deceased.

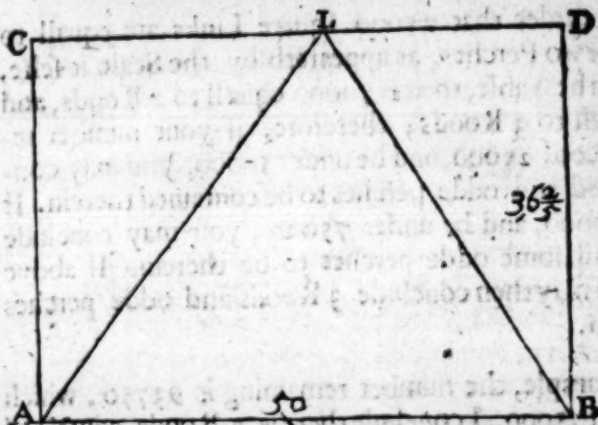
CHAP. XLIII.

Containing divers compendious rules, for the ready casting up of the content of any plain superficies, and other necessary conclusions incident to Surveying, by the line of Numbers.

The line of Numbers is of singular use in casting up of the content of any Superficies, and for land measuring especially Master *Gunter* hath severall propositions, like unto which, I will insert seven other propositions which will be of singular use in the practise of Surveying.

1. The length and breadth of a right angled Parallelogram or long Square being given in Perches, to finde the content thereof in Perches.

As 1 perch, is to the breadth of the Parallelogram in perches,
So is the length in perches, to the content in perches.



In this long Square or Parallelogram ABCD, if the breadth thereof CB be 36 perches, and the length thereof AB 50 perches, the content will be found to be 1820 perches: for,

If you extend the Compasses from 1 to 36; the length, the same extent will reach from 50 the breadth, to 1820, the area or content in perches, which you may reduce into Acres as is taught in the 41 Chap.

2. The length and breadth of a long Square being given in Perches, to finde the content in Acres.

As 160, to the breadth in perches,
So the length in perches, to the content in Acres.

So in the former figure, if the length thereof AB be 50 perches, and the breadth thereof 36, the content will be found to be 11 Acres 40 parts, which is 1 Rood 20 perches; for,

If you extend the Compasses from 160 to 36, the same extent will reach from 50 to 11 Acres 40 parts.

3. The length and breadth of a Parallelogram being given in Chains, to finde the content in Acres.

As 10, to the breadth in Chains,
So the length in Chains, to the content in Acres.

So the length of the long Square AB being 12 Chains 50 Links, and the breadth BC 9 Chains 10 Links, the area will be found to be 11 Acres 37 parts, or 1 Rood 20 perches, for,

If you extend the Compasses from 10, to 9 Chains 10 Links, the same extent will reach from 12 Chains 50 Links, to 11 Acres 37 parts.

4. Having the Base and perpendicular of a Triangle given in Perches, to finde the content in Acres.

As 320, to the Perpendicular;

So the length of the Base, to the content in Acres.

So in the Triangle *L A B*, if the line *B D* be taken for the perpendicular of the Triangle, then the length of the base being 50 perches, and the perpendicular 36 $\frac{1}{2}$, the area will be found to be 5 Acres 22 parts, which is 2 Roods 30 perches, then,

If you extend the Compasses from 320 to 36 $\frac{1}{2}$ the perpendicular, the same extent will reach from 50 the length of the base, to 5 Acres 22 parts.

5. The Base and perpendicular of a Triangle being given in Chains, to finde the content in Acres.

As 20, to the perpendicular;

So the Base, to the content in Acres.

So in the former figure, if *A B* 12 Chains 50 Links be taken for the Base, and *B D* 4 Chains 55 Links for the perpendicular of the Triangle *A L B*, the area (by this proportion) will be found to be 5 Acres 68 parts, that is, 5 Acres 2 Roods 30 perches, therefore,

If you extend the Compasses from 20 to 4 Chains 55 Links, the same extent will reach from 12 Chains 50 Links, to 5 Acres 68 parts, which is 2 Roods 30 perches.

6. The Area or superficial content of any piece of Land being given according to one kinde of Perch, to finde the content thereof according to another kinde of Perch.

As the length of the second perch,

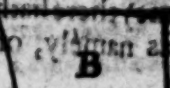
To the length of the first perch;

So the content in Acres,

To a fourth number.

And that fourth number to the content in Acres required.

Suppose the figure *B* were a piece of Land, which being plotted and cast up by a Chain of 16 foot and a half to the Perch, should contain 8 Acres, and that it were required to finde how much the



same

same piece would contain if it were measured with a Chain of 18 foot to the perch: if you work according to the proportion here delivered, you shall finde it to contain 6 Acres 72 parts: for,

If you extend the Compasses from 18 to 16 $\frac{1}{2}$, that extent will reach from 8 to 7.30, and from 7.30 to 6.72, and so many Acres would the figure B contain if it were measured by a perch of 18 foot.

7. Having the length of the Furlong, to finde the breadth of the Acre.

As the length of the furlong in Perches, to 160;
So is 1 Acre, to the breadth in Perches.

So if the length of the furlong be 50 perches, the breadth for one Acre will be 3.20: for,

If you extend the Compasses from 50, the length of the furlong in perches, the same extent will reach from 1 Acre to 3.20 perches.

But if the length of the Furlong be given in Chains, then,

As the length of the Furlong in Chains, is to 10;
So is 1 Acre, to the breadth of the furlong in Chains.

So the length of the Furlong being 12 Chains 50 Links, the breadth thereof will be found to be 08 Chains 80 Links: for,

If you extend the Compasses from 12 Chains 50 Links, to 10, that extent will reach from 1 Acre to 80 Links, which is the breadth of the furlong required.

CHAP. XLIV.

How to reduce one kinde of measure into another, as Statute measure to Customarie measure.

BY the 6 Prop. of the last Chapter you may perform this work by the line of Numbers as is there taught, but however, it will not be amisse in this place to shew how to performe the same Arithmetically, that the reason thereof may the better appear. Now whereas (by the forementioned Statute) an Acre of ground was to contain 160 square perches, measured by the Pole or Perch of 16 foot and a halfe, but in many places of this Nation (through long custome) there hath been received other quantities, called Customarie, as namely, of 18, 20, 24, and 28 foot to the Pole or Perch.

It is therefore necessary for a Surveyor to know how readily to reduce Customarie measure to Statute measure, and the contrary.

Suppose then, that it were required to reduce 5 Acres, 2 Roods, 20 Perches,

*The Irish Acre hath 21 foot to the pole
with the first haps.*

20 Perches, measured by the 18 foot Pole into Statute measure you must seeke out the least proportionall terms between 18 foot, and 16 foot and a halfe, which to performe do thus. Because 16 and a halfe beareth a fraction, reduce 16 and a halfe into halves, and thus both your numbers may be of one denomination, you must reduce 18 (the customary Pole) into halves also; then will your numbers stand thus $\frac{18}{2}$, which abbreviated by 2, by saying how many times 2 in 18: the quotient will be 9, and again, how many times 2 in 36: the quotient will be 18, so will the two proportionall terms between 16 and a halfe and 18, be 12 and 18.

This done, reduce your given quantity (1 Acre, 2 Roods, and 20 perches) into perches, which makes 900 perches: Now considering that what proportion the square of 12, which is 144, bears to the square of 18, which is 324, the same proportion doth the Acre of 16 foot and a halfe to the Perch, bear to the Acre of 18 foot to the Perch.

Now (because the greater measure is to be reduced into the lesser) multiply the given quantity 900 perches, by 144, the greater square, and the product will be 129600, which divided by 324, the quotient will be 399.999 perches, which being reduced into Acres, giveth 6 Acres, 2 Roods, 31 perches, and 11 parts of a perch, according to statute measure.

But on the contrary, suppose it had been required to reduce Statute measure into Customary measure, then you must have multiplied 900 perches (your given quantity) by 324 the lesser square, (because the lesser measure is to be reduced into the greater) the product will be 291600, which divided by the greater square 144, the quotient will be 2025 perches, which reduced into Acres is 4 Acres, 2 Roods 36 perches and a quarter.

The same manner of work is to be observed in the reducing of any Customarie quantity whatsoever.

CHAP. XLV.

How to lay out severall Furlongs in Common-fields unto divers Tenants.



Having plotted the whole Field, Common, or other Inclosure, with its particular bounds, as you observe them in the survey of the whole Mannor, or if you only survey that particular, you must take speciall notice of all the bounds thereof, then provide a Book or paper which must be ruled or divided into 3 Columns, in the first whereof towards the left hand is to be written the Tenants name, and the tenor by which he holds the same Land, the two next Columns are to contain the length of every mans Furlong in Chains and Links. In the two next Columns is expressed the breadth of every mans Furlong

Furlong in Chains and Links, as by the Letters over the head of each column doth appear.

In the three last Columns is to be expressed the quantity of each tenants Furlong in Acres, Roods and Perches.

In the laying out of severall parcels in this kinde, you will have use only of your Chain; then when you begin your work, you must first write the name of the field, and in the first column of your Booke or paper, you must write the Tenants name, and the tenure by which he holds the same, from what place you begin to measure, and upon what point of the compasse you passe from thence, and observing this direction in all the rest, you may (if need require) bound every parcell.

This being noted in your Book, observe the Species or shape of the Furlong, whether it be all of one length or not, if of one length, then you need take the length thereof but once for all, but if it be irregular, that is, in some places shorter and in others longer, then you must take the length thereof at every second or third breadth, and expresse the same in your Book under the title of length. As for the expressing of the severall breadths, you need but to crosse over the whole Furlong, taking every mans breadth by the middle thereof, and entering the same as you passe along, but in case there be a considerable difference at either end, then I would advise you to take the breadth at either end, and adde them together into one sum, then take the half of that summe for your mean or true breadth, and enter it in your Book or paper under the title of breadth.

In this manner you may proceed from one Furlong to another till you have gone through the whole field, which when you have done and noted down the severall lengths and breadths in your book, you may multiply the length and breadth of every parcell together, as is taught before, and so shall you have the quantity of every parcell by it selfe, which quantity must be noted downe in the three last columns of your Book as in the following example appears.

+ rather square
them both and
then add it againe
and take the
root of it whole

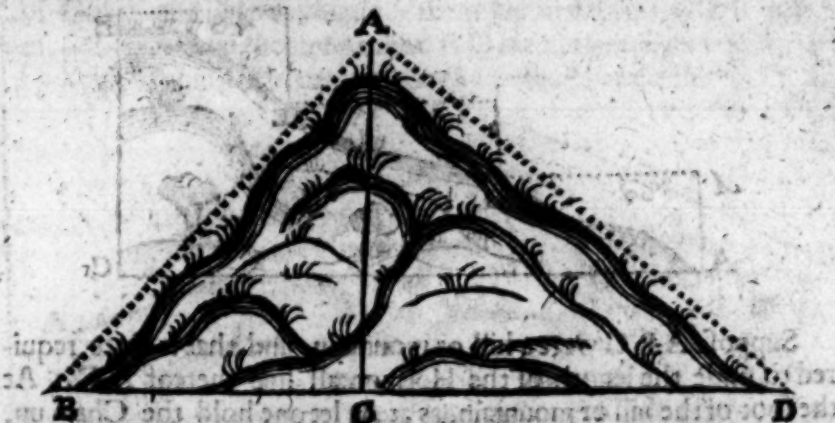
Mordon Field.

The Tenants names and tenure.	Length.		Breadth.		Content.		
	C.	L.	C.	L.	A.	R.	P.
Abel Johnson, from the pond S. E. free.	32	76	3	45	11	1	12
Nicholas Somes, for three lives.	30	12	2	63	7	3	30
Robert Norton, for Life.	28	60	8	12	33	0	36
James Norden, at Will.	25	11	12	35	31	0	2

CHAP. XLXI.

To finde the horizontall line of any hill or mountain.

His proposition differeth nothing from those formerly taught in the taking of Altitudes. Wherefore, suppose you should meet with a hill or mountain as *A B D*, the thing required is to finde the length of the line *B D* on which the mountain standeth.



First, place your Instrument at the very foot of the Hill, exactly levell, then let one go to the top of the hill at *A*, and there place a mark, which must be so much above the top of the hill, as the top of the Instrument is from the ground, then move the Label up and down till through the sights thereof you see the top of the mark at *A*, and note the degrees cut by the Label on the Tangent line, for that is the quantity of the angle *A B C*, which suppose 47 degrees, then by consequence the angle *B A C* must be 43 degrees, the complement of the former to 90 degrees, then measure the side of the hill *A B*, which suppose to contain 71 Feet, then in the Triangle *A B C* there is given the side *A B* 71 foot and the angle *B A C* 43 degrees, together with the right angle *A C B* 90 degrees, and you are to finde the side *B C*, which to perform, say,

As the Sine of the angle *A C B*, 90 degrees,

Is to the side *A B* 71 feet,

So is the Sine of the angle *B A C*, 43 degrees,

To the side *B C* 48½ feet.

Then (because the hill descends on the other side) you must place your Instrument at *D*, observing the angle *A D C* to contain 41 degrees, and the angle *D A C* 49 degrees, and the side *A D* 80 feet: now to finde the side *C D* the proportion will be,

As the Sine of the angle *A C D*, 90 degrees,

Is to the side *A D*, 80 feet,

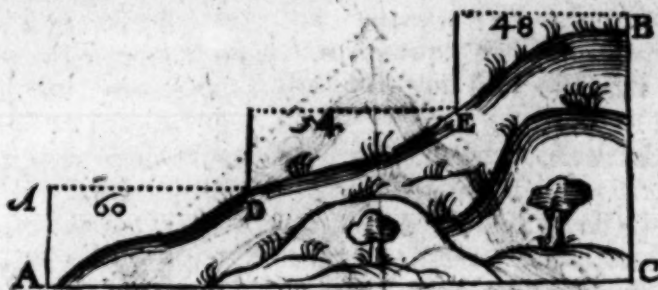
So is the Sine of the angle *C A D*, 49 degrees,

To the side *C D* 60½ feet.

Which added to the line *B C*, giveth 109 feet, which you may reduce into Chains, by dividing it by 66, and this line must be protracted instead of the hypotenuse all lines *A B* and *A D*.

Another way.

There is another way also used by some for the measuring of horizontall lines, which is without the taking of the Hills altitude, or using of any Arithmetical proportion, but by measuring with the Chain only, the manner whereof is thus.



Suppose A B C were a hill or mountain, and that it were required to finde the length of the Horizontall line thereof A C. At the foot of the hill or mountain, as at A, let one hold the Chain up, then let another take the end thereof and carry it up the hill, holding it leuell, so shall the Chain meet with the hill at D, the length A D being 60 Links, then at D let the Chain be held up again, and let another carry it along leuell till it meet with the side of the hill at E, the length being 54 Links: then again let one stand at E and hold up the Chain, another going before to the top of the hill at B, the length being 48 Links, these three numbers being added together make 162 Links, or 1 Chain 62 Links, which is the length of the horizontall line A C. This way of measuring is by some practised, but the other (in my opinion) is far to be preferred before it, only when you are destitute of better helps you may make use hercof.

- But if the hill or mountain should have a descent back again on the other side, you must then use the same way of working as before, and adde all together for the horizontall line.

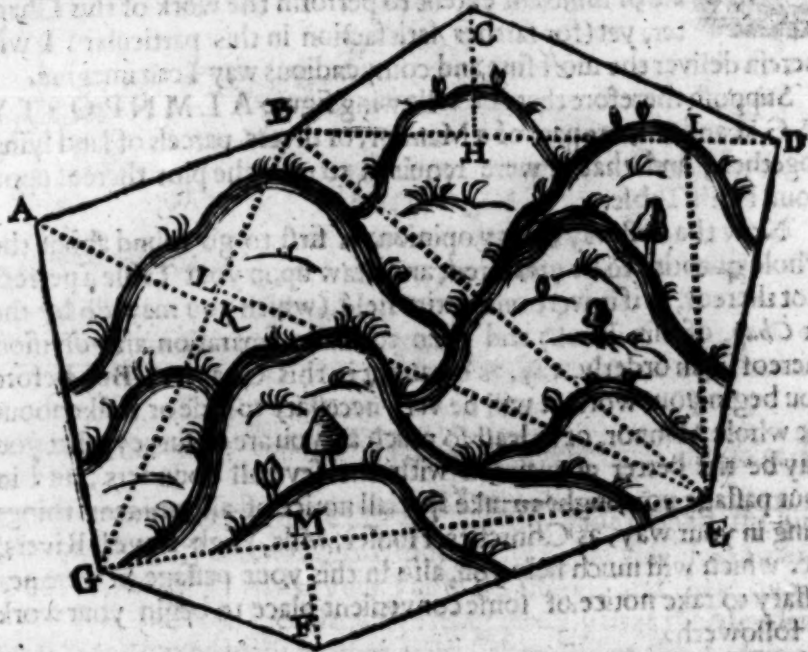
CHAP. XLVII.

How to plot Mountainous and uneven grounds, with the best way to finde the content thereof.

Or the plotting of any mountainous or uneven piece of ground, as A B C D E F G, you must first place your Instrument at A, and direct the sights to B, measuring the line A B, then in regard that from B to C there is an ascent or hill, you must finde the horizontall line thereof, and draw that upon your

Table

Table, accounting thereon the length of the hypothenusall line, then measure round the field according to former directions, and having the figure thereof upon your Table reduce it into Trapezias, as into the Trapezias $A B E G$, $B C D E$, and the Triangle $G E F$; then from the angles $A C E$ and F let fall the perpendiculars $A K$, $C H$, $E I$, and $F M$. Now in regard there are many hills and valleys all over the field, you must measure with your Chain in the field over hill and dale from B to D , and to the line $B D$ set the number of Chains and links as you finde them by measuring, which will be much longer then the streight line $B D$ measured on your Scale; then by help of your Instrument finde the point H in the line $B D$, and



measure with your Chain from C to H , over hill and dale as before, and to this perpendicular $C H$ set the number as you finde it by the Chain: then finde the perpendicular $E I$, and measure that with your Chain also, all which lines (in respect of the hills and vallies) will be found much longer then if they were measured by your Scale: then by the measured lines $B D$, $C H$ and $E I$, cast up the content of the Trapezia $B C D E$. In this manner you must cast up the content of the Trapezia $A B E G$, and the Triangle $G E F$, and this is the exactest way I can prescribe for the mensuration of uneven grounds, which being well and carefully performed, will not vary much of the true content: For it is apparent that if such mountainous grounds were plotted truly according to their area in plane, the figure thereof would not be contained within its proper limits, and being laid down amongst other grounds would swell beyond the bounds, and force the adjoining grounds out of their places, now for distinction in your Plot you may shadow them off with hills as in this figure, lest any man seeing your plot should measure by your Scale, and finde your work to differ.

CHAP. XLVIII.

How to take the Plot of a whole Mannor, or of divers parcells of Land lying together, whether Wood-lands or Champion plains, by the Plain Table.



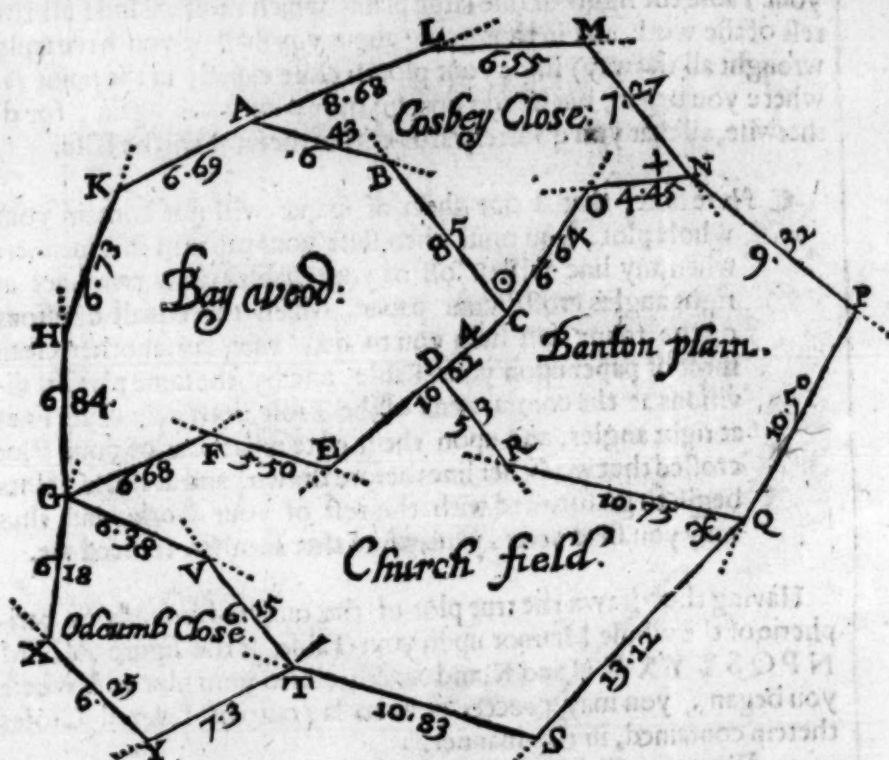
Although practise, in the performance hereof, be better then many words, and that the rules already delivered are of sufficient extent to perform the work of this Chapter, yet (for farther satisfaction in this particular) I will herein deliver the most sure and compendious way I can imagine.

Suppose therefore that the following figure A L M N P Q S T Y X G H and K were part of a Mannor, or divers parcels of land lying together, and that it were required to take the plot thereof upon your Plain Table.

Now the best way (in my opinion) is first to go round about the whole quantity to be measured, and draw upon your Table a perfect plot thereof, as if it were one entire field (which you may do by the 31 Chap. of this Book) and then to make separation and division thereof in an orderly way, as is taught in this Chapter: But before you begin your work, it will be very necessary to ride or walke about the whole Mannor, or at least so much as you are to survey, that you may be the better acquainted with the severall bounders, and in your passage you ought to take speciall notice of all eminent things lying in your way, as Churches, Houses, Mills, High-ways, Rivers, &c. which will much help you, also in this your passage it were necessary to take notice of some convenient place to begin your work as followeth.

Having made choice of some convenient place in the peripherie or outward part of the Mannor, as at A, place there your Table, turning it about till the Needle hang over the Meridian line in the Card, and there fix it, then upon the Table (with most convenience) assigne any point at pleasure, as A, unto which point lay the Index, and turn it about till through the sights you see a mark set up at the next angle at L, then by the side of the Index draw the line A L, which suppose to contain 8 Chains 68 links, take these 8 Chains 68 links from any Scale, and place that length upon your Table from A to L.

2. Bring your Instrument to L, and lay the Index upon the line L A, turning the whole Table about till through the sights you see a mark set up at A where your Table last stood, and there fix it, so will the Needle hang directly over the Meridian line in the Card as before, then lay the Index upon the point L, and turn it about till through the sights you see a mark set up at the next angle at M, and draw a line by the side of the Index, which suppose to contain 6 Chains 55 links, this length being taken from the same Scale as



the former line was, will reach upon your Table from the point L unto M.

3. Remove your Table to M, and lay the Index upon the line M L, turning the Table about till through the sights you espie a mark set up at the angle L, where your Table last stood, and there fixing it, you shall still finde the Needle to hang directly over the Meridian line, if you proceed truly in your work: then laying the Index to the point M, turn it about till through the sights you espie some mark set up at the next angle at N, and draw a line by the side of the Index, then measuring with your Chain from M to N, you shall finde it to contain 7 Chains 27 links, which take from the same Scale as before, and place the length thereof upon your Table from M unto N.

4. Place your Instrument at N, laying the Index upon the line N M, and turn the Table about till through the sights you see a mark set up at your former station at M, and there fix the Table, so will the needle hang over the meridian line as before, then turn the Index about upon the point N, till through the sights you espie the next angle at P, and draw a line by the side thereof, then measure the distance N P 9 Chains 32 links, which take from the Scale, and set it upon your Table from N unto P.

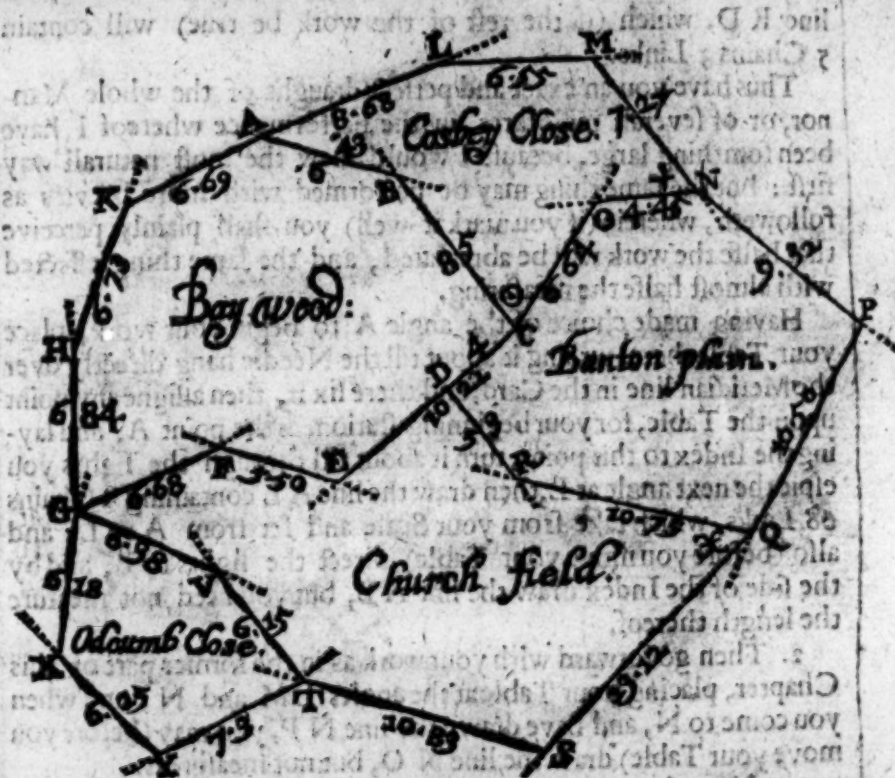
In this manner must you go round about the whole Mannor, making observation at every angle thereof, as at P Q S T Y X G H and K, and setting down the length of every line upon your Table as you finde it by measuring with your Chain, you shall have upon your

your Table the figure of one large plain; which must include all the rest of the work, and in thus going about you shall (if you have truly wrought all the way) finde your plot to close exactly in the point A, where you began, but if it do not, go over your work again, for otherwise, all that you do afterwards within the same will be false.

- ¶ Here note, that if one sheet of paper will not contain your whole plot, you must then shift your paper in this manner: when any line falleth off of your Table, draw two lines at right angles crosse your paper, which the equall divisions on the frame will help you to do; then lay another clean sheet of paper upon your Table, and by the same parallel divisions at the contrary end of the Table, draw two other lines at right angles, and upon them note what part of your Plot crossed the two other lines before drawn, and at those points begin to go forward with the rest of your work: and thus may you shift divers papers one after another, if need be.

Having thus drawn the true plot of the outward bounds or peripherie of the whole Mannor upon your Table, as the figure A L M N P Q S T Y X G H and K, and exactly closed your plot at A where you began, you may proceed now to lay out the severall Closes therein contained, in this manner.

1. Place your Table at A, laying the Index and sights upon the line A L before drawn, and turn it about till through the sights you espie the angle L, and there fixing it, the needle will hang directly over the Meridian line in the Card: then turn the Index about upon the point A, till through the sights you espie a mark set up at the angle B, and by the side of the Index draw the line A B containing 6 Chains 43 Links.
2. Remove the Table to B, laying the Index on the line B A, and turn the Table about till through the sights you see the angle A, then fix it, and turn the Index about upon B, till you see the next angle at C, drawing the line B C by the side of the Index; which suppose to contain 8 Chains 5 Links.
3. Place the Table at C, laying the Index upon the line C B, and turn it about till through the sights you see your former station at B, and there fixing it, turn the Index about upon the point C, till through the sights you see the angle at E, and draw the line C E containing 10 Chains 22 Links which set from C to E, and again (before you move your Table) direct the sights to O and draw the line O C containing 6 Chains 64 links, which take from your Scale and set from C to O, and (because O is the next angle to the bounder) you may (without placing your Instrument at O, or measuring the distance O N) draw the line O N upon your Table, which (if the rest of the work be true) will contain 4 Chains 45 links.
4. Remove your Table to E, laying the Index upon the line E C, and turn the Table about till through the sights you see the angle at C, then fix it, and turn the Index about upon the point E, till you



you espie the next angle at F, and draw the line E F containing 5 Chains 50 Links, which set from E to F, now (because the angle at F is the next angle to the boundary) you may draw the line F G upon your Table without any further trouble, which (if the rest of your work be true) will contain 6 Chains 68 Links.

5: Remove your Instrument to T, laying the Index upon the line T S, and turn it about till through the sights you espie the angle at S, & there fixing it, turn the Index about upon the point T, till through the sights you espie the next angle at V, and by the side of the Index draw the line T V containing 6 Chains 15 Links, which set upon the Table from T to V: now (because VI is the angle next the boulder) you may only draw the line V G, without placing your Instrument at V, or measuring the distance V G upon the ground, which (if the rest of the work be true) will contain 6 Chains 38 Links.

6. Bring your Instrument to Q, and lay the Index upon the line P Q, turning the Table about till through the sights you see the angle at P, then fixing the Table there, turn the Index about upon the point Q, till through the sights you espie the angle at R, and by the side of the Index draw the line Q R containing 10 Chains 75 Links, which set from Q to R,

Lastly, Bring your Table to R, and laying the Index on the line Q R, turn the Table about till through the sights you see the angle at Q, and there fix it, then turn the Index about upon the point R, till through the sights you espy the angle at D, and draw the line

line R D, which (if the rest of the work be true) will contain 5 Chains 3 Links.

Thus have you an exact and perfect draught of the whole Mannor, or of severall inclosures, in the performance whereof I have been something large, because I would shew the most naturall way first: but the same thing may be performed with more brevity as followeth, wherein (if you mark it well) you shall plainly perceive that halfe the work will be abbreviated, and the same thing effected with almost halfe the measuring.

Having made choice of the angle A to begin your work, place your Table there, turning it about till the Needle hang directly over the Meridian line in the Card, and there fix it, then assigne any point upon the Table, for your beginning station, as the point A, and laying the Index to this point, turn it about till through the sights you espie the next angle at L, then draw the line A L containing 8 Chains 68 Links, which take from your Scale and set from A to L: and also (before you move your Table) direct the sights to B, and by the side of the Index draw the line A B, but you need not measure the length thereof.

2. Then go forward with your work as in the former part of this Chapter, placing your Table at the angles L M and N, and when you come to N, and have drawn the line N P, you may (before you move your Table) draw the line N O, but not measure it.

3. Also when you come to the angle Q, and have drawn the line Q S, you may draw the line Q R also, at once placing of the Table.

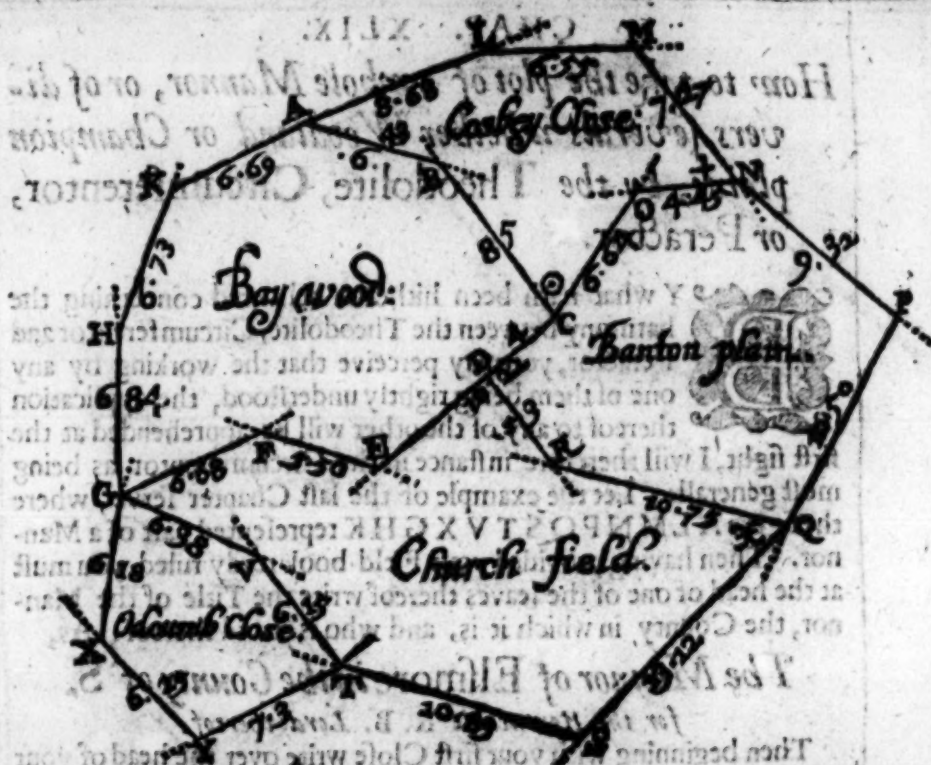
4. When you come to observe at the angle T, and have drawn the line T Y, you may at the same time also draw the line T V, but need not measure it.

5. When you come to the angle G, and have drawn the line G H, you may also draw the line G V, which will cut the line T V in the point V, and at the same time also you may draw the line G F containing 6 Chains 68 Links.

Having thus gone round the whole Mannor, and made a plot of the outward part or peripherie thereof, and also drawn the lines A B, N O, Q R, T V, G V and G F, as you went along the bounder, the remainder of the work will (by this means) be much abbreviated, for you have no more to do, but

1. To place your Table at F, laying the Index upon the line F G, and to turn it about till through the sights you espie the angle at G, and fixing it there direct the sights to E, and draw the line E F containing 5 Chains 50 Links.

2. Place the Table at E, and lay the Index on the line E F, turning the Table about, till you see through the sights the angle F, then fix it, and turn the Index about upon the point E till through the sights you espie the angle at C, and by the side of the Index draw the line E D C, which containeth 10 Chains 22 Links. Then because that from C to D there is 4 Chains, set 4 Chains from C to D and draw the line D R, which will cut the line Q R in the point R, leaving the line D R to contain 5 Chains 3 Links. Last-



Lastly, place the Table at C, laying the Index on the line CE, turning it about till through the Index you see the angle at E, and there fixing it, turn the Index about upon the point C, and direct the sights to Band O, drawing the lines CB and CO. And thus have you upon your Table an exact plot of your Mannor with great ease and celerity.

There is yet another way to perform this work: when you have taken the true plot of the outward bounds or peripherie of the whole Mannor upon a sheet or more of paper, if you will take the pains to go over every particular inclosure again, and draw particular plots of every parcell by the same Scale wherewith you laid down the plot of the peripherie, then over the plot of every particular inclosure, draw parallel Meridians, and when you have thus plotted every particular, if you cut them off by their bouders, and lay them one by another according to their situation within the plot of the whole peripherie, you shall finde that those plots (if your work be true) will justly fill the plot of the whole, leaving no vacancy.

Mm

Char.

M CHAP. XLIX.

How to take the plot of a whole Mannor, or of divers severals whether Woodland or Champion plains, by the Theodolite, Circumferentor, or Peractor.



Y what hath been hitherto delivered concerning the harmony between the Theodolite, Circumferentor and Peractor, you may perceive that the working by any one of them being rightly understood, the application thereof to any of the other will be apprehended at the first sight, I will therefore instance in the Circumferentor as being most generall. Let the example of the last Chapter serve, where the figures A L M N P Q S T V X G H K represented part of a Mannor. Then having provided your Field-book ready ruled, you must at the head of one of the leaves thereof write the Title of the Mannor, the County in which it is, and who is Lord thereof, As,

The Mannor of Elsmore in the County of S.

for the Honourable R. B. Lord thereof.

Then beginning with your first Close write over the head of your Field-book the Tenants name, the name of the Close, and the tenure by which he holds the same, so for the first Close.

Henry Gray, Casby Close, Pasture, Free.
Under this draw a line quite through your Book, then beginning to survey this Close, place your Instrument at A, and direct your sights to L, noting the degrees there cut, which let be 160 degrees 45 minutes, which 160 degrees 45 minutes must be noted in the first and second Columns of your Field-book, then measure the distance A L 8 Chains 48 Links, which place in the third & fourth Columns.

2. Remove your Instrument to L, and direct the sights to M, the needle cutting 121 degrees 30 min. and the line L M containing 6 Chains 55 Links, which note down in your Field-book.

3. Place your Instrument at M, and direct the sights to N, the needle cutting 83 degrees, and the line M N 17 Chains 17 Links, which note in your Field-book. And in regard you are to leave the hedge or bounder A L M N, adjoyning to *Wisby Common*, (which appertaineth to another Mannor, and therefore only the name inserted for your remembrance when you come to protract it,) you must draw a line quite through your Field Book, and in the last Column thereof write *Wisby Common*, which denotes unto you that you are to leave the bounder of *Wisby Common*.

4. Place your Instrument at N and direct the sights to O the needle cutting 355 deg. 40 min. and the distance N O being 4 Chains 45 Links, which note in your Field-book as before.

5. Place your Instrument at O, and direct the sights to C, the needle cutting 309 degrees 30 minutes, and the line O C containing 6 Chains 64 Links, which note in your Field-book.

Now

seeing you are best to begin at C, looke in your Field-book (on the work of the last Close) what degrees and minutes the needle cut at C which were 54 degrees, and 8 Chains 5 Links, therefore against that number make this \odot or the like mark, and write the Title for your second Close thus.

Samuel White, Bay-wood, by Lease,
begin at \odot .

By this means you shall readily know when you come to protraction, where to begin with this parcel, and in the margine place (2) for the number of your second parcel, and then proceed in your work of surveying this parcel as before you did for the other till you have gone round about the same ending at A where you first began, noting down all your observations both of lines and angles, with the particular bounders as you go along in your Field-book, in all respects as you did those of the first Close, and in thus doing you shall finde that at your first observation from C to E, that you went partly by the hedge or bounder of *Banton plain*, and partly by the hedge or bounder of *Church-field*, and therefore against the degrees of that observation write *Banton plain* and *Church-field*, there drawing a line: then at your two next observations at E and F you went along the hedge or bounder of *Church-field*, and at the three last observations at G H and K you went against the hedge or bounder of *Wisby Common*, there finishing your second parcel, wherefore draw a double line quite through your Field-book.

The two parcels being finished, consider which is next fittest to be taken in hand, and where to begin it, which suppose *Banton plain*, and to begin at N, wherefore looke in your field-book what degrees the needle cut when you made observation at N in the surveying of *Wisby Close*, and left the bounder of *Wisby Common*, which degrees you shall finde to be 353 degrees 40 minutes, and 4 Chains 45 Links, therefore at the end of that line where you finde 353 degrees 40 minutes, and 4 Chains 45 Links, make this $+$ or some other mark for a remembrance when you come to protraction, then for the next parcel write in your Field-book.

George Barton, Banton plain, for two lives,
begin at $+$.

This being done place your Instrument at N, and direct the sights to P, the needle cutting 220 degrees 20 minutes, and the line NP containing 9 Chains 32 Links, which note in your Field-book, and because at this observation you went by the hedge or bounder of *Wisby Common*, and are now to leave it, therefore draw a line and write *Wisby Common*, and in this manner must you go about this parcel till you come to close at D, and having finished draw a double line.

Then considering that *Church-field* is next fittest to be surveyed, and that it is most convenient to begin the same at Q, therefore looke what degrees the needle cut at Q in the surveying of *Banton plain*

seeing you are best to begin at C, looke in your Field-book (on the work of the last Close) what degrees and minutes the needle cut at C which were 54 degrees, and 8 Chains 5 Links, therefore against that number make this \odot or the like mark, and write the Title for your second Close thus.

Samuel White, Bay-wood, by Lease,
begin at \odot .

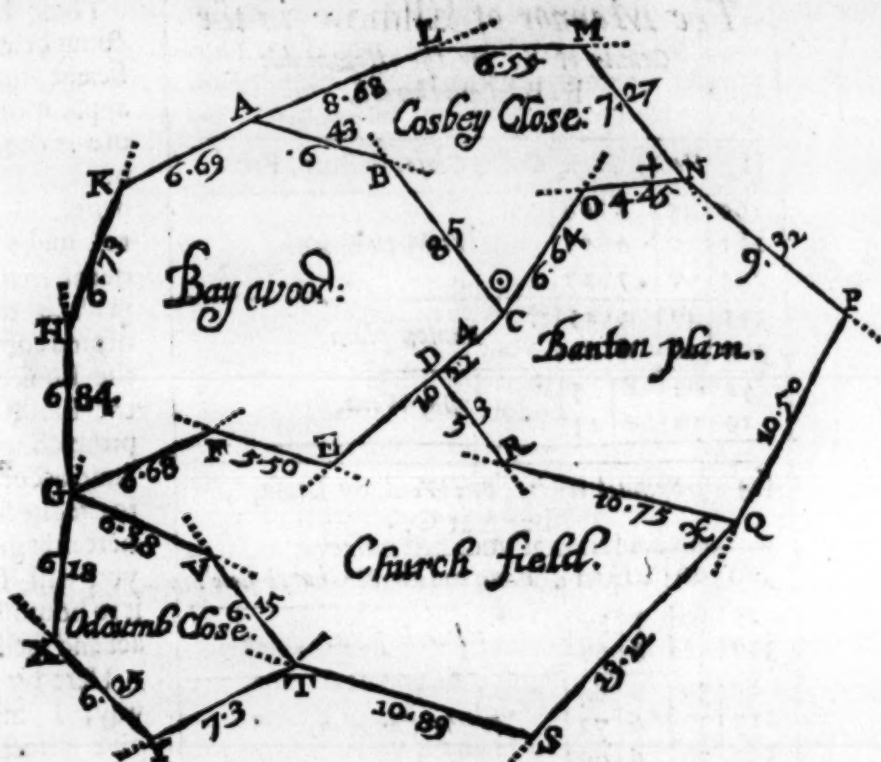
By this means you shall readily know when you come to protraction, where to begin with this parcel, and in the margine place (2) for the number of your second parcel, and then proceed in your work of surveying this parcel as before you did for the other till you have gone round about the same ending at A where you first began, noting down all your observations both of lines and angles, with the particular bounders as you go along in your Field-book, in all respects as you did those of the first Close, and in thus doing you shall finde that at your first observation from C to E, that you went partly by the hedge or bounder of *Banton plain*, and partly by the hedge or bounder of *Church-field*, and therefore against the degrees of that observation write *Banton plain* and *Church-field*, there drawing a line: then at your two next observations at E and F you went along the hedge or bounder of *Church-field*, and at the three last observations at G H and K you went against the hedge or bounder of *Wisby Common*, there finishing your second parcel, wherefore draw a double line quire through your Field-book.

These two parcels being finished, consider which is next fittest to be taken in hand, and where to begin it, which suppose *Banton plain*, and to begin at N, wherefore looke in your field-book what degrees the needle cut when you made observation at N in the surveying of *Wisby Close*, and left the bounder of *Wisby Common*, which degrees you shall finde to be 353 degrees 40 minutes, and 4 Chains 45 Links, therefore at the end of that line where you finde 355 degrees 40 minutes, and 4 Chains 45 Links, make this $+$ or some other mark for a remembrance when you come to protraction, then for the next parcel write in your Field-book.

George Barton, Banton plain, for two lives,
begin at $+$.

This being done place your Instrument at N, and direct the sights to P, the needle cutting 220 degrees 20 minutes, and the line NP containing 9 Chains 32 Links, which note in your Field-book, and because at this observation you went by the hedge or bounder of *Wisby Common*, and are now to leave it, therefore draw a line and write *Wisby Common*, and in this manner must you go about this parcel till you come to close at D, and having finished draw a double line.

Then considering that *Church-field* is next fittest to be surveyed, and that it is most convenient to begin the same at Q, therefore looke what degrees the needle cut at Q in the surveying of *Banton plain*



plain which were 15 degrees 40 minutes, and 10 Chains 75 Links, against which in your Field-book make this * or the like mark for your remembrance, and for your next Close write in your Field-book as followeth.

Thomas King, Church field, by Lease,
begin at x.

Then placing your Instrument at Q, direct the sights to S, noting the degrees cut, and the length of every line measured, with your particular bounders, as you did in the other Closes before, till you come to inclose at G, and when you have done, draw a double line quite through your Field-book, and write the title of the next Close to be surveyed in this manner.

John Nichols, Odcumb Close Free,
begin at —

Then placing your Instrument at T, direct the sights to Y, and note the degrees cut and the lines measured as in those before, till you have gon round the field to G. And thus, if there were never so many Inclosures you may (without confusion) easily distinguish the work of the one from the other, and be able (remembering the premises) to draw a plot thereof at any time, remembering alwayes that those numbers in the Margent of your Book, ought to be placed severally in your Plot in those Closes they represent.

These

*The Mannor of Elsmore, in the
County of S. for the Honourable
R. B. Lord thereof,*

(1) *Henry Grey, Cosbey Close, Pasture, Free.*

160	45	8	68	<i>Wisby Common.</i>
181	30	6	55	
233	00	7	27	
355	40	4	45	+ <i>Banton plain.</i>
309	30	6	64	
54	00	8	5	⊙ <i>Bay Wood.</i>
19	30	6	43	

(2) *Samuel White, Bay Wood, by Lease,
begin at ⊙.*

320	00	10	22	<i>Banton plain, & Church field.</i>
15	30	5	50	<i>Church field.</i>
337	45	6	68	
87	30	6	84	<i>Wisby Common.</i>
113	30	6	73	
153	30	6	69	

(3) *George Burton, Banton plain, for 2 Lives,
begin at +.*

220	20	9	32	<i>Wisby Common.</i>
299	30	10	50	<i>The Forrest.</i>
15	40	10	75	✕ <i>Church field</i>
53	30	5	3	

(4) *Thomas King, Church field, by Lease,
begin at ✕.*

316	20	13	12	<i>The Forrest.</i>
17	15	10	83	<i>Church Lane.</i>
56	00	6	15	<i>Odcumb Close.</i>
24	10	6	38	

(5) *John Nichols, Odcumb Close, Free,
begin at —*

334	30	7	3	<i>Church Lane.</i>
48	30	6	25	
101	30	6	18	

of the work of this Chapter, with the severall lines, angles and bounders, as you observed them in your Survey.

These Instru-
ctions being suf-
ficient for the
application and
use of the Field
book, I shall
desire all men
to make fre-
quent triall and
practise there-
of, and compare
the Book with
the Plot, and
protracting the
same according
to the directions
hereafter given,
you will finde
it to be most ex-
act and facile.

Here by the
way, I might
give directions
whereby to take
in divers sever-
als at once, if
the bounders be
regular, which
will much ease
you both in sur-
veying and pro-
tracting, but by
small practise
this and divers
other abbreviati-
ons will appear
of themselves.

I have here
added one lease
of your Field-
book as it ought
to be ruled, w^{ch}
take for an ex-
ample, it being
the collections

were 160 degrees 45 minutes, therefore against 160 degrees 45 minutes of your Protractor, make a mark, and through that mark and the point A, draw the line A L, containing 8 Chains 68 Links.

Then place the center of the Protractor upon the point L, in all respects as before, and finding your next degrees and length to be 181 degrees 30 minutes, and the length 6 Chains 55 Links, therefore against 181 degrees 30 minutes of your Protractor make a mark, and through it draw the line L M containing 6 Chains 55 Links.

Then place the center of the Protractor upon the point M, and look in your Field-book what degrees were cut at M, protract those degrees (as before) and draw the line M N containing 7 Chains 27 Links.

Then place the center of the Protractor upon the point N, the degrees cut being 355 degrees 40 minutes, and the line N O containing 4 Chains 45 Links, and because against these 355 degrees 40 minutes you finde in your Field-book this mark + there placed, you must therefore (with Black lead or the like) make the same mark at the point N upon your paper, to signifie that you must there begin to protract some other Close.

In this manner must you proceed with all the other lines and angles as you finde them noted in your Field-book, till you have gone over your first Close, and closed your plot at A.

Having thus finished your first inclosure, you must deal in the same manner with the second, third and fourth, and so on, were there never so many. And to know where to begin to protract your second inclosure, you must have recourse to your Field-book, where you shall finde this mark to + which you must begin your second inclosure, which is 101 1/2, and the like mark upon your paper at the point C, which is your remembrancer to put you in minde that at the point C you must begin to protract your second Inclosure, as you did your first Close.

In this manner of protracting there is no difference nor cautions to be observed, more then those already hinted in Chap. 36 and 38 of this Book, viz. that if the degrees to be protracted be under 180, to lay the Semicircle of the Protractor upwards or from you, and if they be above 180, to lay the Semicircle downwards.

Now suppose you were to protract the observations of the last Chapter, having your Field-book before you, consider what way your observations extend, and accordingly begin your work, as in the point A which point A place the center of your Protractor, and draw the line A B, containing 10 Chains 10 Links, and the corresponding divisions at each end of the Scale of the Protractor, lie directly upon one of the parallel meridians, and having the Protractor there, look in your Field-book what degrees and minutes the needle cut in your first observation at A, which

CHAP. LI.

The figure of any plot being given, how to enlarge or diminish the same according to any assigned proportion.

IT may so fall out that when you have taken the plot of a whole Mannor upon your Plain Table, in divers sheets of paper, or observed the angles, and afterwards protracted them, as in the two last Chapters, it may so fall out that your plot may be either bigger or lesser then is desired, now if at any time it be required to enlarge or diminish any plot according to any proportion, this Chapter will accomplish your desire.

The Instruments for the performance hereof are divers, as was intimated in the 9 Chapter of the 2 Book. Now for generality and exactnesse, the two Indexes there spoken of, having at each end thereof a Semicircle, is inferiour to none, but the Instrument being very chargeable, and the use thereof very intricate and tedious, I shall wholly omit to speak any more of it.

There is another way also which Master *Rathborn* used, which was with a Ruler by him invented for that purpose, which would indifferent well reduce a plot from one bignesse to another according to some particular proportions. The making of this Ruler is so well known, and the use thereof so apparent, that I shall not need to say any thing concerning the description or use of it. I only intimate that there is such a Ruler, that those which please may have it made.

Another way is by one line divided into 100 or 1000 equal parts only, which by the help of Arithmetick will perform this work very well, but this (as being very tedious) I neglect.

To passe by these and divers others which I could name, I shall say something of the Parallelogram, which for generality, exactnesse, and dispatch, surpasseth all the rest, unto which (in my opinion) there is none comparable. Of Parallelograms there are diverse sorts, but that which I shall instance in, consisteth but of four Rulers only, the making whereof is well known to the Instrument maker, and the manner of using it is as followeth.

Take the plot which you would reduce, and fasten it to a Table with Mouth-glew, then by it, upon the same Table, fasten your fair paper or parchment, upon which you would have your new plot, then having fitted your Parallelogram according to the proportion into which you would have your plot reduced, fix the Parallelogram to the Table, by a point for that purpose: then put your drawing pen into some one hole on one of the sides of the Parallelogram, and upon it a plummet of lead or brasse to keepe the pen down close to the paper, when it is moved thereupon: and here note, that at any time when the Parallelogram is thus fixed, the point that sticketh

in the Table, the Pen which is to draw, and the Tracer which you must move along the lines of your old plot, will lie alwayes in a right line, but this by the way: Your Parallelogram being fixed to the Table, and the pen in its true place fitted to draw, take the Tracer in your right hand, and with it, lightly go over all the lines of your old plot, so shall the motion thereof occasion the pen to draw upon your clean paper or parchment, the true and exact figure of your former Plot, though of another bignesse, which will be in proportion to the greater according to the situation of the sides of the Parallelogram, which will better appear by the sight of the Instrument, then words can possibly explain it.

CHAP, LII.

How to draw a perfect draught of a whole Mannor, and to furnish it with all necessary varieties, also to trick and beautifie the same: in which, (as in a Map) the Lord of the Mannor may at any time (by inspection only) see the symetry, scituation and content of any parcell of his Land.



Having protracted your plot according to your intended bignesse, and written the content of each Close about the middle thereof, you may about the bounds of every field or Inclosure, with a small Penfill, and some transparent green colour, neatly go over your black lines, so shall you have a transparent stroke of green on either side of your black line, which will adde a great lustre and beauty to your Plot.

Then in your Wood-land grounds, draw diverse little Trees in the most materiall places, and shadow your mountainous and uneven grounds with hills and valleyes, expressing all kinde of Bogs, Groves, High-wayes, Rivers, &c. distinguishing them by lively colours according to their similitudes.

Then in some convenient place of the Plot, without the Inclosures, draw a Circle, and therein describe the 32 points of the Mariners Compasse according to the situation of the grounds, with a Flower-de-luce at the North part thereof.

Then in some other convenient place of your plot, make a Scale equall to that by which your plot was protracted.

Lastly, in some other convenient place towards the upper part thereof, draw the Coat of Arms belonging to the Lord of the Mannor, with Mantle, Helme, Crest, and Supporters, or in a Compartment, but be sure you blazon the Coat in its true Colours.

These



These things being well performed, your plot will be a neat Ornament for the Lord of the Mannor to hang in his Study, or other private place, so that at pleasure he may see his Land before him, and the quantity of all or every parcell thereof without any further trouble.

Also in your plot must be expressed the Mannor-house according to its symetry or situation, with all other houses of note, also all Water-mills, Wind-mills, and whatsoever else is necessary, that may be put into your Plot without confusion.

For farther explanation of what hath been delivered in this Chapter, I have here added the figure of a small Mannor, which will be sufficient for example sake.

Nn 2

CHAP.

CHAP. LIII.

How to finde whether water may be conveyed from a Spring head, to any appointed place.



Here is an Instrument called a Water-Levell, for the performance hereof, the making whereof is sufficiently known. Now if it were required to know whether water may be conveyed in Pipes or Trenches from a Spring head to any determinate place, observe the following directions.

Place your Water-Levell at some convenient distance from the Spring head, in a right line towards the place to which the water is to be conveyed, as at 30, 40, 60, or 100 yards distant from the Spring-head. Then having in a readinesse two long streight poles (which you may call your station staves) divided into Feet, Inches, and parts of Inches from the bottome upwards: being thus provided, cause one (whom you may call your *first assistant*) to set up one of the said staves at the Spring head, and require another (which you may call your *second assistant*) to erect the other staffe beyond your Instrument at 30, 40, 60, or 100 yards forward, towards the place to which the water should be conveyed. These station staves being erected perpendicular, and your Water-Levell in the mid way precisely horizontall, go to the end of the Levell, and looking through the sights, cause your *first assistant* to move a leafe of paper up and down your station staffe, till through the sights you see the very edge thereof, and then by some known signe or sound, intimate to him that the paper is then in its true position, then let this *first assistant* note against what number of Feet, Inches, and parts of an Inch the edge of the paper resteth, which he must note down in a paper. Then your Water-Levell remaining immoveable, go to the other end thereof, and looking through the sights towards your other station staffe, cause your *second assistant* to move a leafe of paper along the staffe, till you see the very edge thereof through the sights, and then (by some known signe or sound) cause him to take notice what number of Feet, Inches, and parts of an Inch, are cut by the said paper, which will him also to keepe in minde, or note in a paper as your *first assistant* did.

This done, require your *first assistant* to bring his station staffe from the Spring head, and cause your *second assistant* to take that staffe and carry it forward towards the place to which the water is to be conveyed, 30, 40, 60, or 100 yards, and there to erect it perpendicular as before, letting your *first assistant* stand at that staffe where your *second assistant* before stood; then in the mid way between your two assistants, place your Water-Levell exactly horizontall, and looking through the sights thereof, cause your *first assistant* to move a paper up and down, and when you give him a

signe

signe to note what number of Feet, Inches, and parts of an Inch are cut by the paper, and note them down, then going to the other end of your Water-Levell, look through the sights, and cause your *second assistant* to move a paper along the Staffe, and to note the Feet, Inches, and parts of an Inch as before.

Then cause your *first assistant* to bring away his station-staffe, and cause your *second assistant* to take it and carry it 30, 40, 50, or 100 yards forward towards the place to which the water is to be conveyed, and leaving your *first assistant* at the place where your *second assistant* last stood, place your Water-Levell again in the mid way between your two Assistants, and looking through the sights as before, cause each of them to move a leaf of paper up and down their station staves, and note down in their severall papers the number of Feet, Inches, and parts of an Inch cut, when you looked through the sights of your Water-levell.

In this manner you must go along from the Spring head, to the place unto which you would have the water conveyed, and if there be never so many severall stations, you must, in all of them, observe this manner of work precisely, so by comparing the notes of your two Assistants together, you may easily know whether the water may be conveyed from the Spring head to the desired place or not.

¶ Here note, that in your passage between the Spring head and the appointed place, from station to station, you must observe this order, otherwise great error will ensue, viz. that your *first assistant* must at every station, stand between the Spring head and your Water-Levell: and your *second assistant* must always stand between your Water-Levell and the place to which the water is to be conveyed, thus by observing this order in your work you shall have no confusion, neither shall one of your Assistants take more pains then the other.

Having thus orderly proceeded from the Spring head to the place appointed, call both your Assistants together, and cause them to give in their notes of the observations at each station, and adde them together severally: then if the note of the *second assistant* exceed (or be greater then) the note of the *first assistant*, take the lesser out of the greater, and the remainder will shew you how much the appointed place to which the water is to be brought is lower then the Spring head.

The First Assistant's Note.

Station	Feet	Inch	parts
1	15	3	$\frac{1}{2}$
2	2	1	$\frac{1}{4}$
3	1	6	0
Sum	18	10	$\frac{1}{4}$

The Second Assistant's Note.

Station	Feet	Inch	parts
1	3	2	$\frac{1}{2}$
2	14	0	$\frac{1}{4}$
3	3	11	0
Sum	20	13	0

By

By this Table you may perceive that the notes of the *first assistant* collected at his severall stations being added together, amounteth to 18 Feet, 10 Inches, and $\frac{1}{2}$ of an Inch: and the notes of your *second assistant* at his severall stations being added together amounteth to 21 Feet and 2 Inches, so the number of the *first assistants* observations being taken from the number of the second, there will remain 2 Feet, 3 Inches and $\frac{1}{2}$ of an Inch, and so much is the place to which the water is to be brought, lower then the Spring head, according to the streight Water-Levell, and therefore the water may easily be conveyed thither.

¶ Here note, that when you have called your two Assistants together, and examined their severall Notes, and added them together, if then you shall finde the Summe of your *first assistants* Note to be greater then the Summe of your *second assistants* Note, that then it is impossible to bring the water from that Spring head to the intended place: but if the Summes of the Notes of your two Assistants do exactly agree, there is then a possibility of effecting it, if the distance be but short, though with more charge and difficulty.

¶ Note 2, That the most approved Authors concerning this particular do aver, that at every miles end there ought to be allowed $4\frac{1}{2}$ Inches more then the streight Levell, for the current of the water.

¶ Note 3, If there be any Hill lying in the way between the Spring head and the place to which the water is to be conveyed, you must then cut a Trench by the side of the Hill in which you must lay your pipes equall with the streight water levell, with the former allowance. And in case there be a Valley you must then make a Trunk of strong wood well under-proped with strong pieces of Timber, and well pitched or leaded, as is done in diverse places between *Wars* and *London*.

¶ Note 4, That in your conveying of water to an appointed place, it is not convenient to bring it from the Spring head by the neereſt distance or in a streight line, but by a crooked or winding way, and you ought also to lay the pipes one up and another down, but this is to be observed but in some cases only, where the water will have too violent a current.

Another way.

There is another way whereby you may know whether water will be brought to any place or not, which in very large distances ought to

to be considered. Take the distance between the Spring head and the place to which the water is to be brought, which multiply in it selfe, adde the product thereof to the Square of the Earths Semidiameter, *viz.* to the square of 3436, $\frac{1}{2}$ Italian miles, then out of the product thereof extract the Square Root, and then from that Square Root take 3436, $\frac{1}{2}$ miles, the remainder is the difference between the line of levell, and the water or circular levell.

Thus have I finished my intended discourse of Surveying of Land, in which I have studied rather to make every particular therein contained plain and perspicuous to the meanest capacity, then with too much brevity to obscure that which I chiefly aimed at, namely, to instruct the ignorant: I confesse I may be justly blamed by those who are Masters of the Art, or have a considerable knowledge thereof already, for using too many circumlocutions, but I answer, it was not written for their sakes, yet I hope it will not be rejected by them, and although I do not attempt to teach such more then they know already, yet (possibly) they may herein finde something worth their perusall and practise, or (at least) it may be a remembrancer unto them to bring to minde what otherwise they may have forgotten: But ceasing to apologise any more for my Book, let it now speak for it selfe.

